TELESCOPE MAKING 4

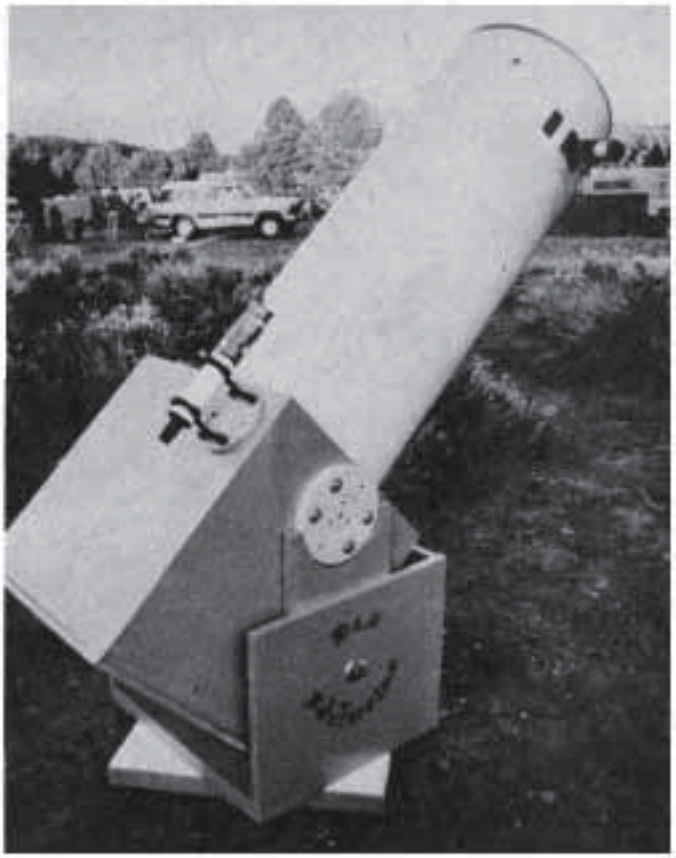
The magazine *for, by,* and *about* telescope makers! Summer 1979

Whatever Happened to "Telescopes for Beginners?"

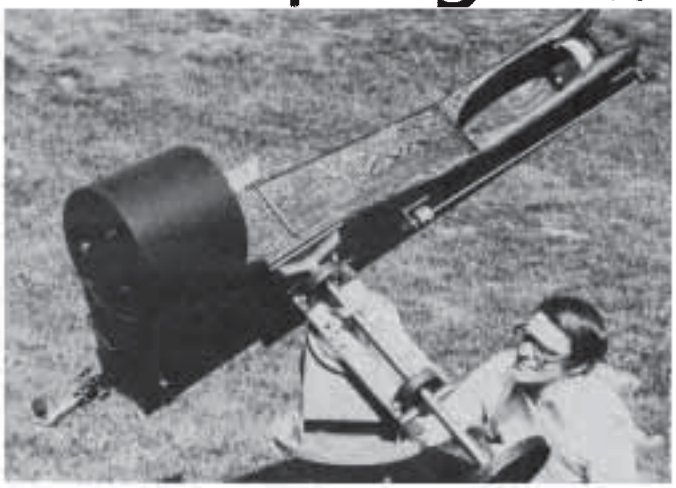
"Telescopes for Beginners" will appear in TM issue #6. It suffered from a deadline set too early (May 1), from the late mailing of TM#2, and, to some extent, from reader apathy. To do justice to the those designs submitted and gather enough more that the issue will be of service to beginners, we decided to postpone "Telescopes for Beginners" until issue #6 (Winter 1980). The new deadline for submissions will be November 15, 1979. See the full announcement on page 3, under "TM6."

Dobsonians

see pages 4 and 32



Pennsylvania amateurs build a 10" Schiefspiegler *page* **8**



RIVERSIDE 1979

A report on the annual Riverside Telescope Makers Conference — see page 24

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TELESCOPE MAKING

The magazine *for*, *by* and *about* telescope makers!

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Editorial

As this issue pulls together, it's obviously going to be another 48-pager. Reader response to the "vote with your wallet" subscription extension appeal was extremely good; and whatever else comes of it, I think you can rest assured that TM is here to stay. Now, I don't want to belabor the point, but if you didn't extend your subscription, now is the time to renew it. There should be a form with a computer-generated label on it enclosed if you're up for renewal; please don't set it aside and forget it. We won't be sending out a long string of reminders — once you're gone, you're gone.

I'm sure I've spelled somebody's name wrong, gotten some technical facts scrambled, or somehow inadvertantly slighted someone or something in the Riverside meeting report. I know I got carried away in my estimate of the number of 16″ telescopes in the ASTRONOMY Forum article (I said a dozen, but can only remember six specifically). For these errors I apologize. But it was a heck of a meeting, I enjoyed covering it, and I fully intend to go back next year. By the way, only about 25 cents of each subscriber's money went into financing my trip for TM.

Special thanks for the production of this issue are due to Dianne Precourt Cuneo, Kathy King, Robert Burnham, and Nancy Faustmann; all ASTRONOMY staffers, who put in extra time and effort for TM every three months.

Sincerely,

Richard Berry

P.S. Oh, yes — I'll be at Stellafane this year, July 28/29, and hope to meet the eastern contingent of TM readers.

Letters

Refractor Buff

Dear Sirs / How nice it was to learn about your new magazine, TELESCOPE MAKING. It is very timely for me as I have just purchased an 8" f/13.3 objective lens for a refractor I'm hoping to assemble. When I began the project (and I have just received the lens), I did not realize how little was in print on the construction of refractors, and especially on suitable mounts. All the many little details loom quite large when so little seems to be available for reference.

My intent was to assemble various stock items, as many as possible, so as to make unnecessary the design and original construction of components. However, it seems most manufacturers cater to the reflectors, and act as if they don't want to be bothered when you write asking about the suitability of a focuser or an eyepiece for use with a refractor. I hope you will be able to publicize sources of parts needed in the assembly and construction of both refractors and reflectors, since I fully intend to build a nice-size reflector after completing the refractor.

Wishing you much success in your new venture, I am

Sincerely yours,
Willard E. Strain
1508 Dug Gap Road
Dalton, GA 30720

Dear Mr. Strain / You might consider building a simple alt-azimuth mounting such as Steve Smith describes in TM2 (just to get started) and then switch later to an instrument more closely resembling Jeff Schroeder's refractor (pictured in this issue). The mounting, as you've probably realized, must be doubly stiff in a refractor because of the long moment arm of the typically lengthy tube.

We are hoping that more manufacturers will join our classified listing (The Blue Pages) so that TMs such as yourself can quickly identify sources for needed parts. In the meantime, perhaps a few of the more ambitious firms — and perhaps a few helpful readers — will contact you directly. Good luck with your scope.

-- R. L. B.

Help!

Dear Sir / I am 29 years old and have a young man of 12, who along with myself, is quite interested in building our own telescope.

We are complete beginners in the science of astronomy, but we are quite enthusiastic about tackling such a project. We are also looking into the possibilities of constructing a mini-observatory.

Our finances are quite limited, but we would appreciate any help or suggestions that would help us get started.

Thank you for your time.

Mark J. Armijo
5917 W. Colter
Glendale, AZ 85301

Dear Mr. Armijo / The 4" f/10 reflector plans published in ASTRONOMY (October 1978, page 42) may be just what you're looking for. This telescope is quite easy to build as a first

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Information for TM Authors

If you're preparing an article for TM, you can help us by following these easy guidelines.

Type your article — if at all possible — double-spaced on white paper, leaving margins of at least 1" on the left and 1½" on the right. We prefer that you use a 50-character line length. Don't worry about getting a perfect copy — that's unnecessary effort on your part — but please use a ribbon dark enough to read. Make large corrections neatly in pencil in the margins, not between the lines. Don't worry about writing too much; between seven and eight pages of typewritten copy fit on a single page set in type. And it's easy for us to condense if it's too long.

Letters to the editor may be handwritten.

We prefer black and white prints (5x7 or 8x10), b&w negatives, color negatives, color prints, and transparencies, in that order. We can reproduce from any of them, so if you don't have b&w prints, don't let it stop you. We like lots of pictures — the more the better.

Line drawings and diagrams should be inked or done with a very dark black marker. Lettering should be as neat as possible. You may work up to twice size; we can reduce it.

TM5

Grinding, polishing, and testing telescope mirrors is the topic for TM5. Every aspect — from tips that save time, fancy methods of testing, grinding machines, how to make focograms, group projects for instructing mirror-making — if it's about mirrors, it's for TM5. Deadline: Sept. 1, 1979.

TM6

Telescopes for beginners can be more challenging than the most advanced designs. Why? You're forced to consider simple materials, simple techniques of fabrication, and cost — all while trying to obtain the very best possible performance. We'd like plans for basic instruments in the 3" to 6" aperture range suitable for school classes, people isolated from the help of other telescope makers, and those just getting started in the hobby of telescope making. Deadline: Nov. 15, 1979.

Subscriptions to Telescope Making

Subscriptions to **Telescope Making** cost $8 per year (four issues) and $16 for two years (eight issues). You may start your subscription with any issue you wish. Use the form below, or, if you don't want to damage the magazine, send a photocopy or reasonable facsimile with the information requested. Payment must accompany your order. Clubs or groups may inquire about group rates and bulk orders.

☐ Please enter my subscription for one year (4 issues). Payment of $8 is enclosed.

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tm-4

The Dobsonian Telescope: Part I

It's STABILITY that Counts!

Dobsonian mountings give those people who wish to explore the heavens, with an eye much larger than their own, a problem-free telescope. They have the easiest-to-use, most trouble-free, and most transportable big telescope design available. Their performance has been tested in the field and the design has evolved through experience. Dobsonian mountings, and indeed the entire Dobsonian telescope concept, *are not* intended for long exposure astrophotography, micrometer measurements of double stars, photoelectric photometry, astrometric plates for parallax measurement, spectroscopy, or infrared radiometry. They *are* intended for looking, and seeing, with a telescope that helps you rather than hinders you.

The structural design of the mounting, called the rocker, is the key to the telescope's success. The rocker is an unusually stable method for carrying a very massive telescopes. It allows very little shake or vibration, uses simple materials, and responds with buttery smoothness. This is due mainly to the on-axis support, for unlike most equatorial mountings, the rocker carries the weight of the telescope directly over its own center of gravity. Equally important, the weight of the telescope is never borne through a single shaft to the ground.

The rocker carries a large box which in turn supports the telescope tube. The side bearings (disks on the sides of the box) rest on four teflon pads, two on either side of the rocker. The base of the rocker rotates on three pads of teflon against a smooth surface (such as Formica) called the bottom bearing. The simple gravity design of the two bearings makes play in the bearings impossible. The simplicity of these teflon bearings makes it possible to build them in unusually large sizes. You'll commonly find 8″ to 12″ side bearings and 16″ to 20″ bottom bearings for a 16″ telescope. Bearing diameters of this size — and their advantages — are rare in portable telescopes.

The friction of the bearings is easily adjusted to satisfy personal taste. The large teflon bearings allow the telescope to move smoothly, while leaving enough friction so that the telescope, when bumped or in windy conditions, doesn't move without your wanting it to. These bearings, when properly constructed, don't suffer from backlash either: when you center a star in the field of view and release the telescope, the star remains centered. Backlash is a common and frustrating problem in many telescopes.

In the structural parts of the telescope, metal is almost always avoided. One of the worst enemies of the observer is telescope vibration. In some telescopes a momentary touch on the focusing knob can set off vibrations that seem to go on a lifetime. Getting the telescope in good focus becomes a chore at high power. This doesn't happen with Dobsonian telescopes because wood mountings and cardboard tubes are very effective in dampening out vibration. They don't make church bells out of wood!

Alt-azimuth designs offer an important, but seldom mentioned, advantage to you optical workers: it allows the use of thin glass for large mirrors. Because the mirror only has to be supported along one edge, you can support the mirrror the same way opticians do in the optical shop: with a sling around the bottom.

Supporting a thin mirror in an equatorial mount is difficult because the tube rolls. Providing support that works without warping the glass in any of the positions the mirror can get to is tricky. But an alt-azimuth telescope tilts in only one plane, hence it is possible to support the mirror's edge by means of hanging it in a sling. This gives an even support of the mirror's edge — almost impossible to obtain in a telescope where any part of the mirror's edge may be asked to support the weight of the mirror.

Supporting the back of a thin mirror is just a matter of a good flotation support, nine or eighteen points depending on just how thin the mirror is. And "just how thin" depends on how far you are willing to go. The San Francisco Sidewalk Astronomers' two largest telescopes are 24″ diameter by 1″ thick and 22″ diameter by 1¼″ thick. In large amateur telescopes, one inhibiting factor is the cost (and weight) of standard-thickness Pyrex blanks. Dobsonians make use of plate glass portholes and Pyrex sheet glass, good alternatives because they weigh and cost much less.

A 16″ Dobsonian fits neatly into the back of a VW squareback for trips into dark-sky country.

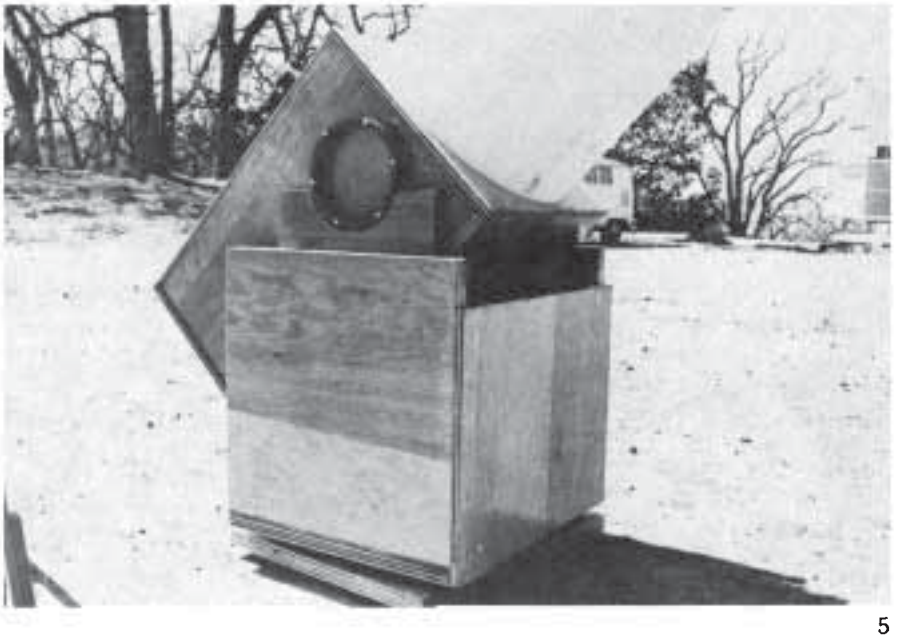
Eyebrows are raised, on occasion, at the idea of plate glass portholes: "Didn't plate glass go out after World War II?" Well, it did with conventional thickness mirrors, and for good reason: after all, it has three times the thermal coefficient of expansion of Pyrex. However, what counts is thermal equilibration; and a thin plate glass mirror, say a 16" diameter by 1" thick, equilibrates to temperature changes four times as fast as a standard thickness Pyrex mirror of the same diameter.

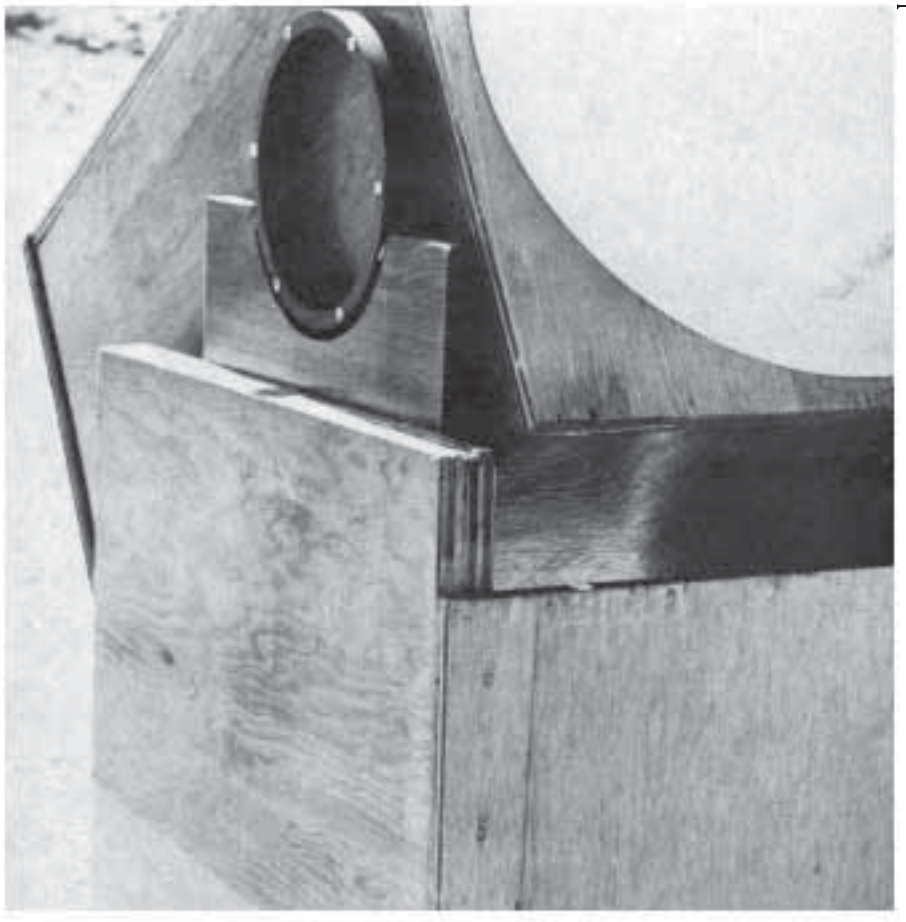
On the basis of my own experience with telescopes, especially with the bigger ones up to 24 inches, the whole question of the mirror changing its figure while the telescope is cooling off in the early evening is moot. Turbulence, inside the tube and around the telescope, is always the overwhelming problem, and it affects all large telescopes. By the time the air in and around the telescope has settled down, the mirror has equilibrated sufficiently. In wood and cardboard-tubed instruments, where the mirror is a major source of heated air, the speedy equilibration of the thin mirror means you're ready to observe sooner. (And if it still bothers you, there's always sheet Pyrex glass, still a lot cheaper than molded blanks.)

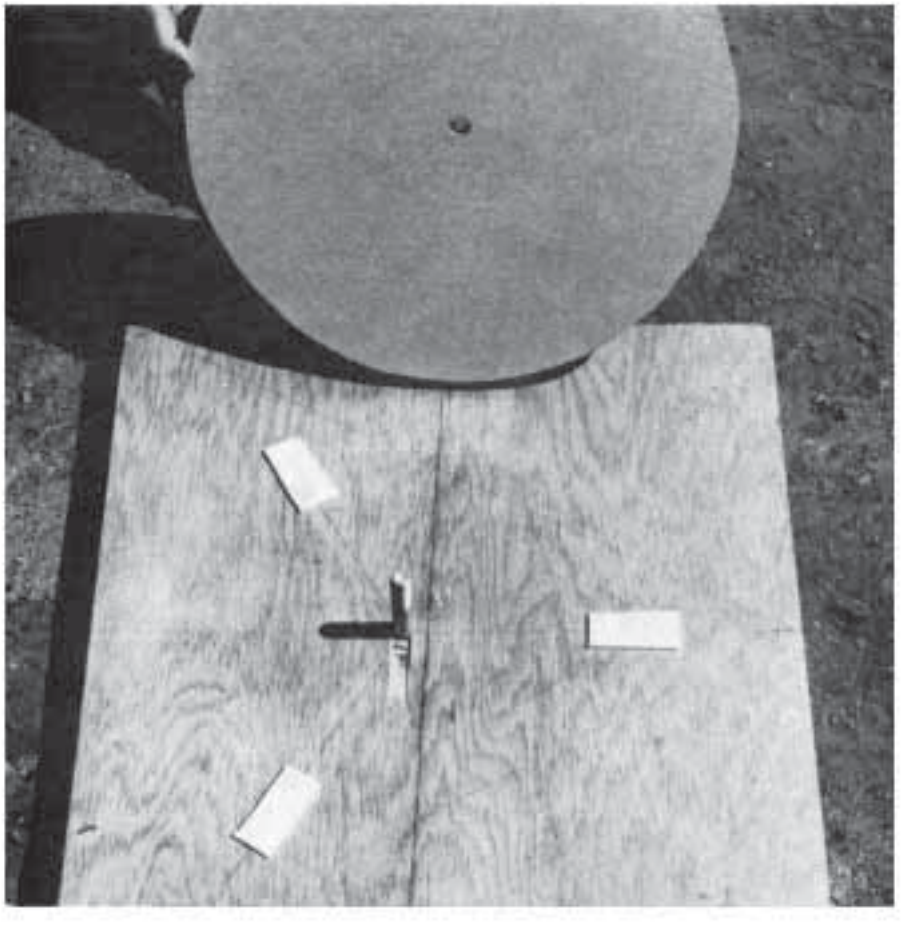
What do we have when we step back and look at a Dobsonian telescope? There is nothing to make a machinist ecstacise — no knurled knobs, gears, or precision metal parts. For the electronically-minded there are no wires, switches, power requirements, or converters. For the opticians, there is only one parabolic mirror and one secondary flat — no correctors or erectors — just a simple Newtonian reflector.

For the observer, proof of an instrument's

Above: After the two-hour drive to Fremont State Park, everybody wants to take a look through the telescope. Dobsonians are ideal at star-parties. Below: This telescope's mounting is unpainted; it is therefore ideal for observing construction details. The side bearings are made from a short piece of PVC tubing riding on teflon pads.







Stability

worth comes only when the telescope is hidden under the dark of night, so let's take a test run on a 16" f/5. (By the way, the mounting doesn't have to be used on big telescopes; it works with smaller ones just as well.) Imagine yourself standing next to it still wondering how a 16-incher could have come out of a Volkswagen Square Back so easily and quickly. You're in the mountains, one of the marvels of portable aperture, and after twilight your remote observing site reveals its pitch black sky.

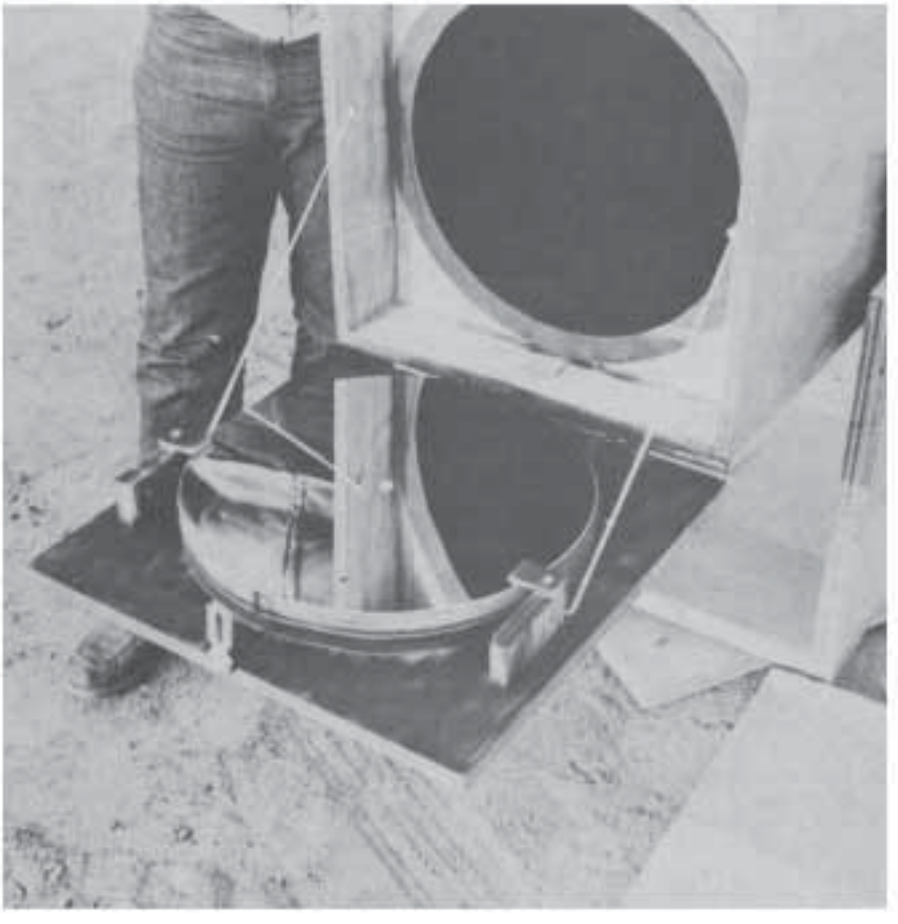
Your head tips up, you mumble "Where's M-13?", then you spot Hercules nearing the zenith. You grab the telescope and begin moving it; right away you feel just how smooth a telescope can move. Without any fuss at all the telescope is pointing in the right direction and you put your eye to the finder's eyepiece and center the little fuzzy spot on the cross hair. You pull away and notice that the finder, no matter where you point the telescope, always remains on the top of the telescope. "How convenient!", you think. Two steps up the ladder and your eye goes to the eyepiece; you give the telescope a little nudge, centering the cluster in the field. Next you focus. No shake. "It's really steady!" And M-13: you can hardly believe it. The cluster almost fills the eyepiece field; you can resolve right across it with absolutely no effort whatsoever. You stare for awhile, so excited you don't even notice your hand nudge the telescope re-centering the cluster in the field.

You think to yourself, "If this is 100 power what must 200 look like?" In goes the high power eyepiece; you focus and stare for awhile. "I can see right through it," you say to some friends anxiously waiting a turn at the eyepiece. Again the scope gets a nudge re-centering the object. Then you realize at 200 power you can nudge the telescope and M-13 moves into the center and just sits there. There's no vibrating or wiggling — you don't have to wait for it to subside. Then you think again, "How smoothly it moves!" Quickly you come to understand how simply the telescope operates without a clock drive. It just doesn't need one! After a couple hours of observing, the nudging of the telescope becomes second nature. You don't even realize you're doing it even at high powers for observing the planets. After awhile you stop and notice that the eyepiece is always pointing in the same direction — horizontal. It never ends up at the top or the bottom of the tube where you can't reach it, but always out to the side, perfectly comfortable, and the eyepiece never falls out.

Bob Kestner
1261 Davis Ave.
Concord, CA 94518

■

Above: The rocker, made almost entirely of plywood, is part of the secret of the Dobsonian's stability. Below: The bottom bearing is extremely simple. Teflon is nailed to the ground board; the formica sink cut-out rides face-down on the teflon. The rocker rides on the back of the sink cut-out.



Top: The 16" x 1" plate glass mirror resting on a 9-point flotation and hanging in its sling. "The night this picture was taken," says Bob Kestner, "the turbulence was as absent as I've ever seen it. At 600x the Airy disk was clearly seen with perfectly round star disks just on either side of focus denoting the absence of any problems with astigmatism." Bottom: The mirror sitting face-up on the telescope's "tailgate." A combination lock keeps the mirror safe from curious fingers while it's in the telescope. The mirror is transported in the plywood box seen on the ground.

Editor's Note: Bob Kestner, in his letter accompanying this article, says: "I now have more respect for authors of magazine articles. The article was rewritten over ten times with several people giving advice. I hope dividing the article into two parts is acceptable. First we want to give you reasons to build a sturdy alt-azimuth telescope; then we'll show you how." That's fair enough, but I'll bet a lot of people besides me will sit on the edges of their chairs until TM#5 comes out! Bob points out that even though the design looks simple, "it's the little things that make or break it. For instance, the teflon on the bottom bearing has to be face up. This seems trivial, but if you face the Teflon down and the formica up, dirt settles on the formica and then the teflon runs over the dirt. You can imagine what this does; it makes the bottom bearing feel like the R.A. axis of (a certain brand-name telescope). In Part II, I'll outline these little things plus give advice on construction. It would take several articles to do this right, but I feel in one more article I can get the TM started in the right direction."

At the Riverside meeting, I saw a number of Dobsonians in action, and as you will realize from reading my article, I rather enjoyed using them. They are everything that Bob Kestner claims them to be, and more. I used a largish number of more conventionally-mounted instruments, including one 16-incher that must have weighed a ton or more, and can only remark that the stability of the Dobsonians is exceptional. He's right about the optical quality too; it's superb in those I saw.

In case you're wondering where the term "Dobsonian" comes from, it's the adjectival form of John Dobson's name. John Dobson is a key member of the San Francisco Sidewalk Astronomers, a group that has put on hundreds of star parties for people all over the western states. (Watch for an article in **Sky and Telescope** *about their activities.)*

This nomenclature should be applied only to instruments closely related to the instruments Bob Kestner describe. Mike Hatcher's 22-inch alt-az, for example, is not a Dobsonian, but belongs to a class sometimes called "Big Box" telescopes. *R.L.B.*

Constructing a 10″ Kutter Schiefspiegler

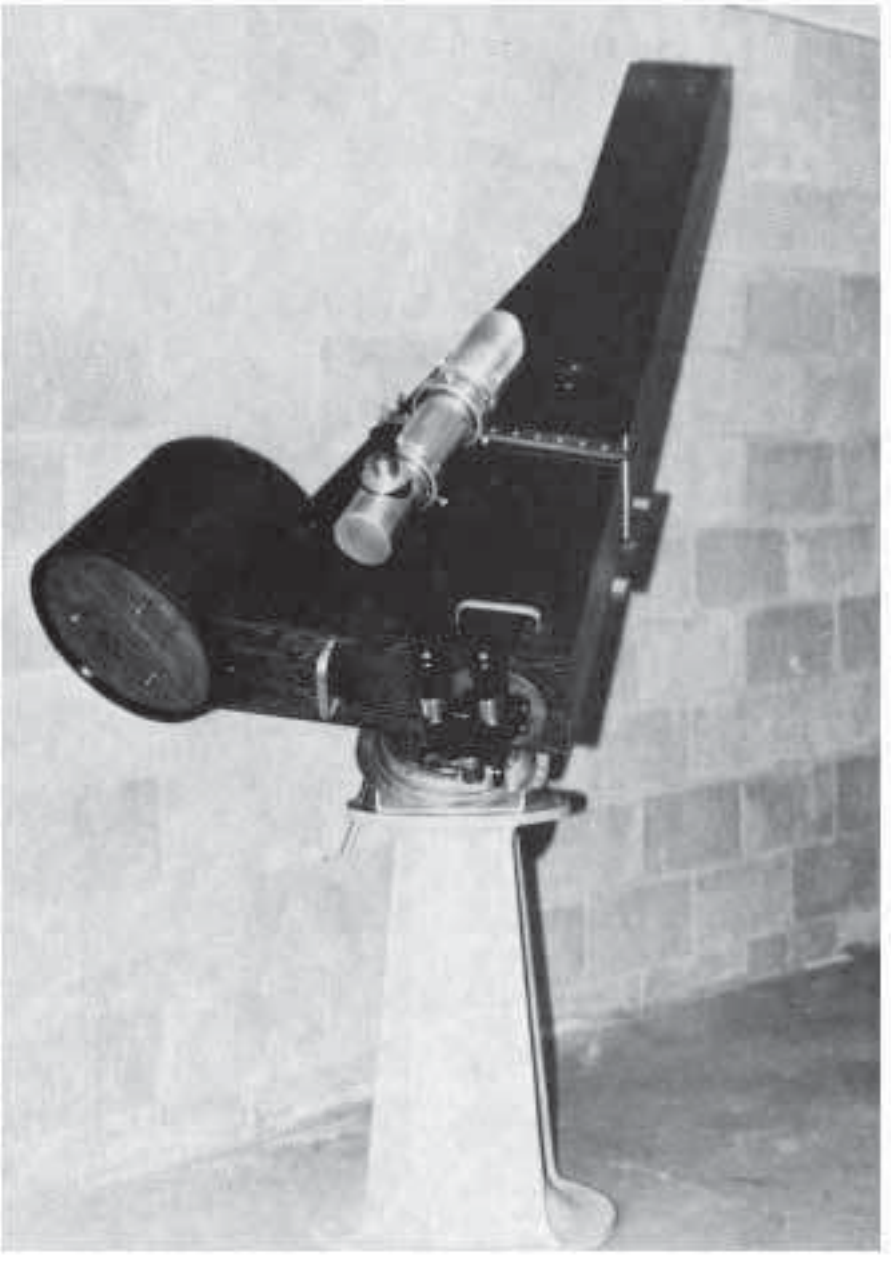
by
Robert A. Schmidt

The dream of three Pittsburgh observers was finally realized when we completed our 10″ TCT (Tilted Component Telescope), of the type known as a Kutter Schiefspiegler. Our inspiration had its roots in the early 70s with the construction of a 4¼″ inch Schiefspiegler. This honest-to-goodness unobstructed reflector, although modest by present-day standards of aperture, showed images of such high order that it became embarrassing at local observing sessions when the telescope outperformed other instruments with apertures up to twice its size!

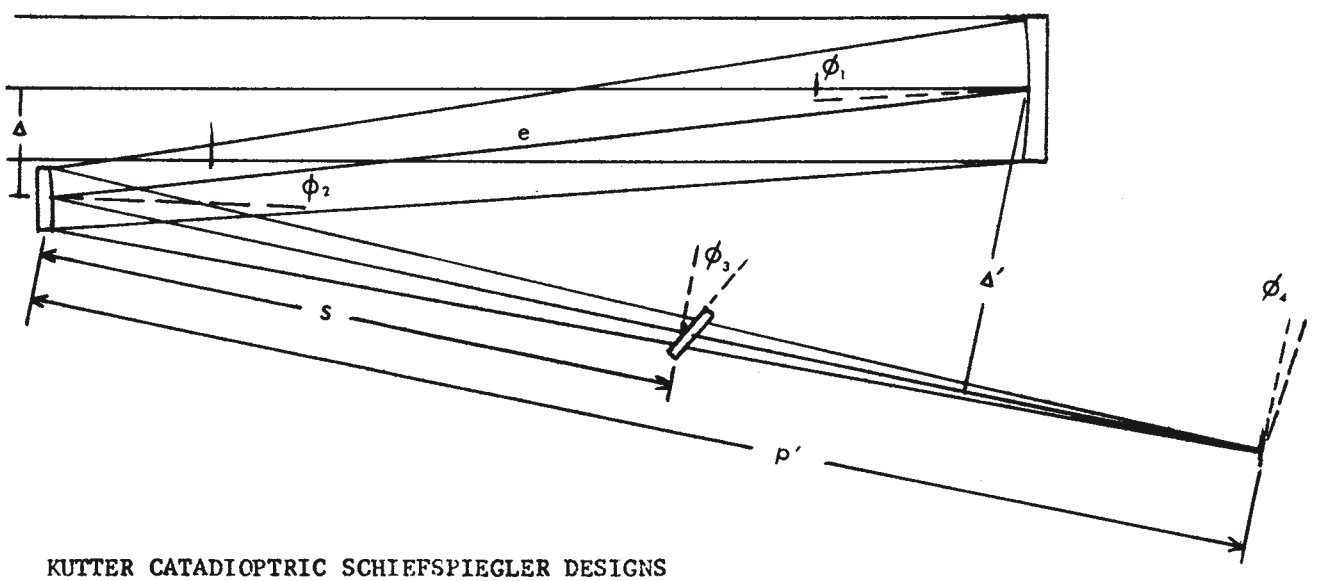
Whether or not others were impressed wasn't the final intent of our going to a 10″. *We* were impressed — and that was all that was important. Since the three of us worked at regular jobs, it became a part-time project that didn't become a reality until a good three years actual working time had passed. It's worth noting that it doesn't really take three people to make a large TCT, it just happened that we had identical desires at the same time, or in overlapping time frames, and so chose to work together.

When attempting any high-quality telescope, only the finest glass should be used so the final figuring will be stable and hold true throughout a wide range of temperature. Mirrors of fine annealed Pyrex, or similar glass, satisfy this criterion, however, and the high cost of special low expansion glass-ceramic material isn't justified in view of the average worker's limited budget. The lens should be made of fine annealed Crown glass, BK-7 or BSC-2, (517645) grade A, but grade B can be substituted if cost is a problem.

We worked the primary mirror just like any regular concave surface and tested it with the Foucault test to a smooth and regular spherical figure. We had some trouble obtaining specification figures for a 10″ Schiefspiegler and its correcting lens, and finally used those obtained for a modified design by Hub Sherman in Minnesota. He changed the original Kutter parameters in order to obtain a focal ratio faster than the f/20 Kutter design, but he could only reduce it to an f/16.8. This small change resulted in larger tilt angles of the optics and the final focal plane, which are not desirable in any TCT instrument. We now recommend you stick



Schiefspiegler Specs



KUTTER CATADIOPTRIC SCHIEFSPIEGLER DESIGNS

D_1	6.00	8.00	10.00	12.50	Primary Mirror - Pyrex
t_1	1.0	1.2	1.6	2.0	(55% of parabolic
R_1	-144.0	-192.0	-240.0	-300.0	correction)
D_2	2.8	3.8	4.6	5.83	
t_2	0.4	0.6	0.6	1.0	Secondary Mirror - Pyrex
*R_2	-152.0	-202.8	-253.6	-316.67	
D_3	2.6	3.4	4.2	5.2	
R_3	0	0	0	0	Correcting Lens
t_3	0.20	0.28	0.32	0.42	Glass - 517645
R_4	-465.3	-620.4	-775.5	-969.4	
EFL	120.0	160.0	200.0	250.0	
e	41.00	54.64	68.28	85.42	Separations
p'	51.32	68.68	85.80	107.33	
Δ'	13.64	17.00	21.28	26.58	
Δ	4.80	6.00	7.52	9.42	
s	22.0	29.84	37.28	46.67	
** ϕ_1	3° 22'	3° 09'	3° 09'	3° 09'	Angles
** ϕ_2	9° 43'	9° 04'	9° 04'	9° 04'	
ϕ_3	30°	30°	30°	30°	
** ϕ_4	7° 15½'	6° 46'	6° 46'	6° 46'	

* It is recommended that this be changed to the same radius as R_1 to make the fabrication and testing easier. No major change will result but there will be a change in p' of several inches and the focal plane tilt will change by 3 minutes of arc, both are insignificant in construction and performance.

**Note the mirror tilt angles and focal plane tilt on the 6 inch optics are not the same as on all the other sizes!

10" Schiefspiegler

with the original Kutter specifications for best results.

Smoothness of the optical surfaces is a critical parameter in a TCT design if you want to achieve the low contrast definition possible with the unobstructed light path. If you're not used to working long radii, you'll find the surface annoyingly "rubbery," changing rapidly in radius and surface smoothness. The secret in figuring such a surface is good contact, short working spells, and a slow steady stroke in moving the glass over the lap. Turned-edge should be avoided. If necessary, grind off the edge zones because the small loss in diameter is more than offset by the increase in definition and overall performance by its absence.

The secondary, a convex surface, has the same radius as the primary, making it possible to use the center of the tool for this mirror. Since the design only calls for a 5" diameter section of the surface, it isn't necessary to completely polish or figure the entire surface. It is, however, necessary to grind and dummy-polish the back of the tool so it's possible to see through it for testing. But it can be a really crude surface with no figure; pits and even scratches are of no consequence.

After making a concave lap and polishing until the convex surface has enough shine to reflect light, carefully place it face down on the concave mirror and interference test against the primary for figure and radius. As only the central 5" are important, make a 10" mask with the center 5" cut out and put this over the back of the tool. You might as well save the effort of testing any part that won't be used. For viewing the fringes, a low cost method is to use an uncoated blacklight fluorescent light bulb and appropriate ballast with a piece of green plexiglass as a filter to isolate the 5461 Angstrom line of Mercury light, diffusing the light with a piece of white paper. It isn't necessary to have a filter as large as the glass, because you can filter the light anywhere in the optical path: a small piece of green plastic or cellophane film held in front of your eye as you view the test works well.

Due to the thickness of the finishing abrasive, the two surfaces will not match. If the surface match is convex, pressing down at the center of the tool will cause the rings that form between the surfaces by interference to move outward from their bull's-eye center showing the radius of the convex mirror is shorter than the test mirror. If the pattern moves so the rings move toward the center, the secondary is longer (flatter) relative to the mirror.

If the test shows strong convex differences, say 10 rings, make a 6" concave polishing lap and work on the center of the tool. This will rapidly flatten out the surface and it will soon approach the right radius. When a match of four or less rings is obtained, switch to the full-size lap for more control of smoothness and figure. A radius match to within two rings with the bull's eye centered on the glass is sufficient if, when they are decentered, the edges of the fringes are smooth and regular. Two fringes, or one wave of light, represent only a difference of radius of slightly more than $\frac{1}{8}$", well within tolerance.

When the convex secondary is polished out and spherical, biscuit-cut it from the large disk with a drill press and a hollow tube about $5\frac{1}{4}$". In biscuit cutting, always protect the mirror face with masking tape and use a smoothing abrasive to cut slowly into the glass so as not to relieve any strains that might be present.

After cutting through, bevel the edge $\frac{1}{8}$" to prevent chipping and to true up the surface. A secondary made this way is thicker than necessary, but this does no harm except adding a bit more weight to the assembly at the upper tube end and another few minutes of temperature adjusting.

Now the mirrors are finished — well almost! We left the primary spherical so we could use it as a test plate for the secondary; actually its figure should be an ellipsoid, in our case with a correction of about 45% of a full paraboloid. For a paraboloid, with just the knife-edge moving, the shift is r^2/R or $5^2/196$ which equals 0.1276". 45% of that is 0.0574". This is not very much, so slow and careful figuring is needed to change the surface without overcorrecting it.

As the drawing of the optical system shows, a 10" TCT like this one has a correcting lens. It is needed for the telescope to perform properly, although in the smaller sizes up to $4\frac{1}{4}$" this lens is unnecessary (see TM 1, pp. 4-7). Basically then, this is a catadioptric Schiefspiegler, employing both mirrors and lenses to achieve its final correction. (See the August 1978 ASTRONOMY Magazine for a general discussion of catadioptric systems with small lenses.)

For the Kutter Schiefspiegler, the correcting lens is plano-convex. The specifications indicate that the convex surface has a very long radius of curvature, in this case 862" or about 72'. We made a test plate from a piece of grade B crown glass, grinding the shallow concave surface on it using a spherometer for radius control (the sagitta is 0.0027"). Thank heaven, it was summer when we made this surface: the concave test surface was on the far inside wall of the shop (40' long), and the test path ran across the 30' lawn outside and onto the neighbor's lawn! With a flashlight, the center of curvature was located and the surface tested. The spherometer got us to within 6" of the proper radius on two tries, but that's just beginner's luck for you! As a full polish wasn't needed on the test glass, it was possible to obtain radius and keep a smooth spherical figure without too much work.

The lens surface was worked with the spherometer as a guide until it showed the correct radius. Any variation we tried to keep on the plus side. It was polished and fringe-tested against its test plate until a straight line pattern was obtained using the Mercury light source described earlier. The flat side was polished and tested against a 1/20 wave master flat to within $\frac{1}{8}$ wave, which is much better then necessary.

The finished lens is not coated but we've noticed no detrimental effects due to this in observing through the telescope. True, there is some light loss, but the objects are so brilliant now through the 10" aperture that it didn't seem necessary to fuss about the light lost due to surface reflections.

Those worrying about chromatic aberrations introduced by a single-element lens can rest assured that the residual color is about 60% less than a first-class doublet and 20% less than the classic apochromatic triplet lens; the color produced by residual chromatic aberration is therefore virtually nonexistant. We've seen more color in the image produced by a Newtonian with a Kellner ocular than you'll ever see in the Schiefspiegler using the correcting lens.

Cells for the components were fashioned from $\frac{1}{4}$" finished plywood. The drawings included in this article for the secondary and lens cell show the suggested way to mount the optics.

Due to fabrication variations in radii, allow some adjustment in the tube assembly so it'll be possible to adjust out the differences. Kutter, in his writings, recommends that the optics be breadboard tested on a table, bench top, or temporary framework, adjusting until a good image is obtained of either a star or laboratory artificial star at the focus of a collimator. You can then measure the exact location of each part and design and build the final tube. Our first setup was a crude plywood framework with spacings and tilts according to the table of specifications. It wasn't pretty, but it worked.

Initial alignment was made indoors with an artificial star placed at the focus of Wade Barbin's 10" Newtonian. We removed some coma seen at first by tilting the lens and changing the spacing of the primary mirror's center to the final optical axis until a decent image of the artificial stars was obtained. Next, we put it on an equatorial mount and pointed at some first and second magnitude stars. These showed some small changes in mirror, and lens tilts were still required to get round star images, but there remained a bit of a smear at the bottom of the image. In spite of this, views of Jupiter and the Moon were outstanding, even though Jupiter still showed this smearing effect at the bottom of its image. Guessing that we had reached the practical limit of alignment in the crude test structure, we went ahead with the construction of the tube.

The tube assembly (or perhaps it should be called the box assembly) is built of finished $\frac{1}{4}$" plywood, stained and varnished. All joints where wood meets wood are glued and fastened with countersunk flathead wood screws. As the pictures show, it's necessary to leave out, or cut out, openings to allow the light cone to reach the secondary mirror. The primary mirror tube is supported in a piece of $\frac{3}{8}$"-thick cardboard tubing, 14" long obtained from a rug distributor. We shellacked it to seal the cardboard and painted it flat black inside and out.

A plastic tube 36" long with a $\frac{1}{4}$" wall houses the lens cell and focuser. This tube is aligned with the secondary, which is attached at the focusing end to the wooden housing at the end of the saddle. Rigidity is the important factor in constructing any TCT so the components will stay put and in alignment with each other on a permanent basis. Constructional details are shown in the accompanying photographs.

A vent 3" in diameter was cut in the box assembly on the eyepiece end between the primary mirror and focuser to permit trapped warm air to escape from the housing.

A 3" f/5 finder with an elbow eyepiece is affixed to the telescope; you'll note that it's angled to the tube due to the tilt of the light path relative to the unit. Handles on the rear of the telescope help in carrying it out to the

mount and in moving it around the sky in observing.

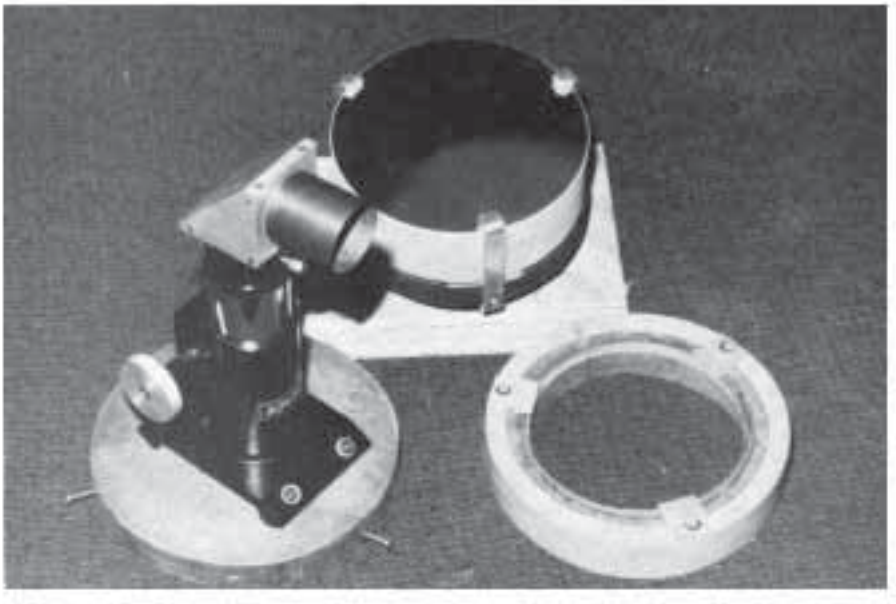
This time, we decided to do the alignment by the recommended method (i.e., by placing targets over the primary mirror and at the secondary end of the scope in the incoming light path). One detail essential for easy alignment is that the mirror cells have one of the adjusting screws in the meridional plane for changing tilt without disturbing the mirror position.

With a bull's-eye disk placed over the primary mirror, the secondary was adjusted to bring the target image concentric with the secondary mirror and a peephole located at the eyepiece position. Once made, this adjustment will seldom be changed if the cell is properly made. After the target is removed, a second target is hung at the secondary end of the tube with its center coinciding with the ideal position of the center of the incoming light beam from a star. In the accompanying picture both targets are shown in place on the telescope, but this was done so their location could be more clearly seen by the reader. Next the primary mirror was adjusted so the outside ring of the target was concentric with the edges of the primary and secondary mirrors as seen from the focuser. Star tests now showed the smear gone from the image — it was all a matter of doing things right. Our breadboard alignment was off by several turns of the adjusting screws due to trying to align only by eye.

The correcting lens specifications call for the lens to be wedged by about 2 minutes of arc but it was made concentric and then decentered in the light path by ⅝" above the optical axis of the instrument. Results have been fine and this was much easier to do than making a wedged optical element.

Views in our telescope are so outstanding it's diffcult to find words to describe them. Few observers have had the chance to view through a 10" aperture first-class refractor, but this is the view obtained, and with just about no visible color either. (Many have compared this Schiefspiegler to the Allegheny Observatory's famous 13" Clark refractor!) Jupiter, in periods of good seeing, is so sharp one would think they were viewing from outside the atmosphere. With a stereoocular and 1000 power (that's 100 per inch of aperture, a severe test for any telescope) the lunar foothills around Plato were observed under excellent seeing — "a sight never to be forgotten" is the only way to describe it.

There is a moral to this project -- never give up! I started this project back in 1972, but when I could find no specific design parameters I became discouraged and sold the unworked glass to Robert Scherer, a friend who was then a staff member of the Allegheny Observatory and a draftsman for a local firm. Working at Three B Optical, a firm in Gibsonia, Pennsylvania, under the owner, Bill Herdman, the optics were finished in about a year's time.



Top: Smoothing and filing the secondary end cutout is necessary for good appearance. Middle: Installing the secondary cell into the tube with woodscrews; note the extra-thick secondary mirror. Bottom: The secondary mirror, corrector lens cell, and focuser mount before installation.

10″ Schiefspiegler

Unfortunately, intervening higher priorities on his time, and his moving into an apartment with limited space, prevented Bob from assembling and null-testing out the optics. He finally gave the optics back to me and suggested I assemble them in a telescope tube. At this point, another friend, Wade Barbin, who has a nice garage and workshop (as well as better skies), was interested in mounting the instrument. Wade had worked full-time for Three B and Goerz Optical for several years and had an excellent diffraction-limited 10″ f/8 paraboloid for his Newtonian which could be used for indoor testing.

Therefore, three people really were responsible for this fine telescope. I did the design acquisition, optical consultation, collimation and testing, photos, drawings and this article. Robert Scherer did the optical fabrication, and Wade Barbin designed the tube assembly and made the mount.

Robert A. Schmidt
127 Bateman Street
Pittsburgh, PA 15209

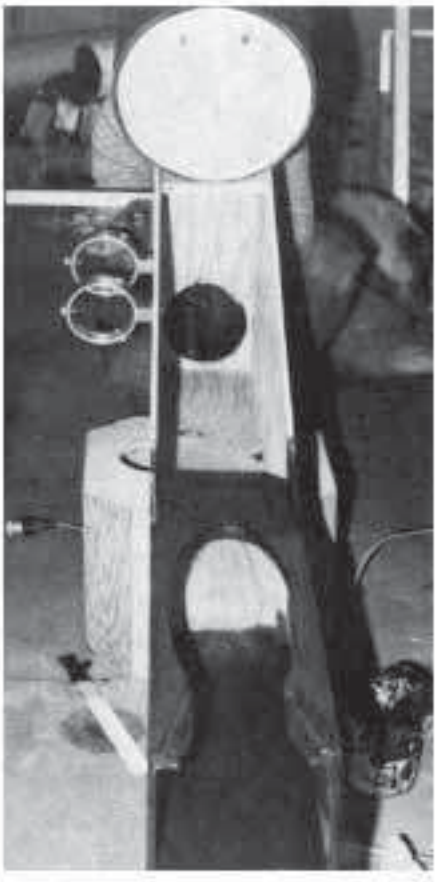
ED NOTE: Bob Schmidt wrote to me at the end of December 1966 asking for information on building a refractor as a change of pace from the diffraction limited 8″ Schmidt Cassegrainian he had just completed. Having made a 4¼″ Kutter Schiefspiegler myself in 1962, I encouraged him to make one of them instead. He decided on the Schiefspiegler in February 1967 and completed it in May of that year. In a subsequent letter he wrote how with only 100 power Mars showed a polar cap and several green markings, and how Jupiter was a breathless sight with seven belts plus a moon in shadow transit at only 80 power. At the Allegheny Observatory, he said, a 4″ Brashear refractor had been the standard of excellence before the Schiefspiegler, which had now become the standard for small aperture telescopes.

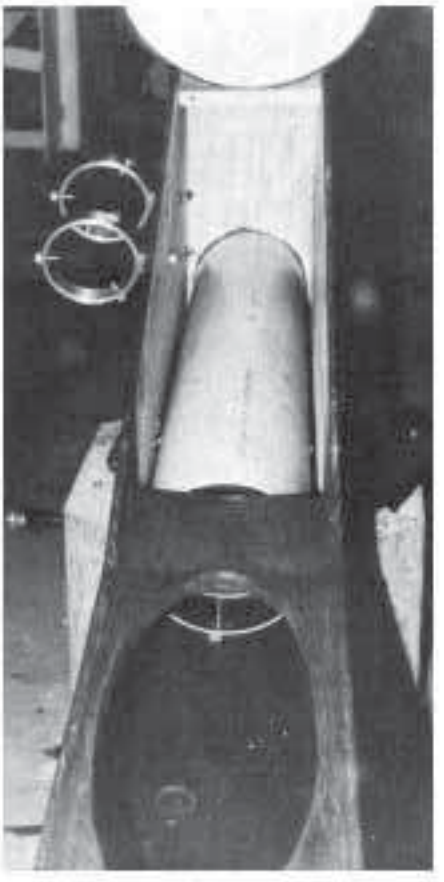
Over the years of correspondence he never failed to praise the definition of the TCT and it was, therefore, most gratifying to see him finally mount a large-aperture Schiefspiegler. It isn't surprising, though, for once an observer has used a TCT in good seeing conditions, it's impossible to be pleased with any obstructed form of optical instrument.

What makes the TCT so outstanding? Can the lack of a central obstruction be so important to image quality? The answer is that it certainly seems to be.

Two important qualifiers must be noted in the high performance of the TCT: first, the optics must be excellent and well aligned; and second, seeing conditions must be perfect or much better than average. Another reason the TCT performs so well is the final focal ratio of the system, f/20 or f/26, permits eyepieces to work better.

It is important to realize that even a TCT cannot perform better than optical theory. Resolution is aperture-limited, as it is in all telescopes; however, the sight of hard, sharp, round Airy disks surrounded by a uniform, bright, spurious ring at 125 power on Castor is an inspiring sight to an observer. Double stars can be seen elongated with separations of about 0.8 seconds of arc, both with only a 4¼″ aperture. So why do people prefer the small size Schiefspiegler to larger size reflectors?





Left: The telescope housing minus the corrector/focuser assembly receives a coat of stain; note the hole for the corrector/focuser tube in the rear of the housing. Right: the corrector/focuser assembly in place. The adjusting screw at the end of the tube allows accurate angling of the tube.

I believe principally that the contrast of the TCT is so outstanding that it can never be equaled in any obstructed instrument. The closest performance approaching that of a TCT I've ever seen was a 6″ f/15 Newtonian having an unusually small central obstruction.

Newtonians, of course, do suffer from secondary obstruction. But the major reason for their failure is that more than 95% arrive out of alignment and more often than not are never checked or realigned. Also, the steeper light cone on the faster Newtonian is not as favorable to the eyepiece operation.

It was unfortunate that Mr. Schmidt did not have the proper Kutter specifications for his instrument, but it performs well on the parameters he used. However, the smaller the tilts of the mirrors and final focal plane, the better the instrument will perform. I strongly recommend that those considering making a large aperture TCT use the original parameters by Anton Kutter, the designer of the Schiefspiegler. These have been converted from metric, hence the odd sizes on the apertures, but you can still use the standard Pyrex disks and still apply the specifications with no changes in the figures.

In making a large Schiefspiegler using the tool for the secondary, in order to reduce the thickness, you might consider using a 6″ Pyrex disk for the tool in grinding the primary, because working with a sub-diameter tool is relatively easy on so long a radius. This will reduce the thickness to one inch. However, in polishing and figuring the primary, I recommend you use a full size tool.

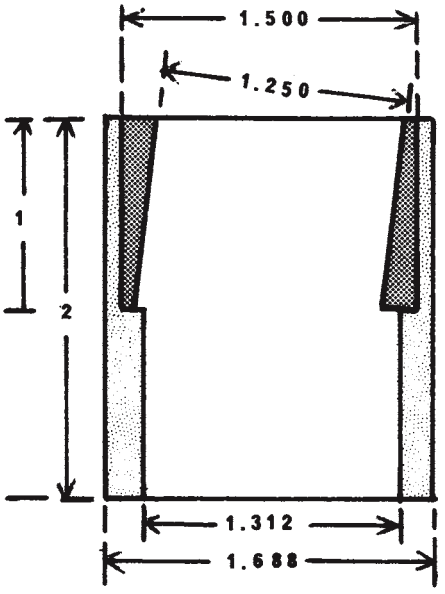
The tilted focal plane should not be ignored and must be allowed for if you want to obtain maximum field definition. Although the present instrument has obviously worked well, allowing for the tilt would be especially important in photography. Visually the eye can average out the focus across the ocular and since the differences will be small, you won't notice the problem. But film is not so forgiving.

In correcting the tilt of the focal plane, it is the eyepiece that must be tilted, NOT the tube carrying the eyepiece. This is an important difference. The best solution is to have an oversize eyepiece tube and insert a liner into which the tilt has been machined. Another solution is to make a cap that goes over the outside of the regular eyepiece tube and which contains the tilted insert to be used in photography.

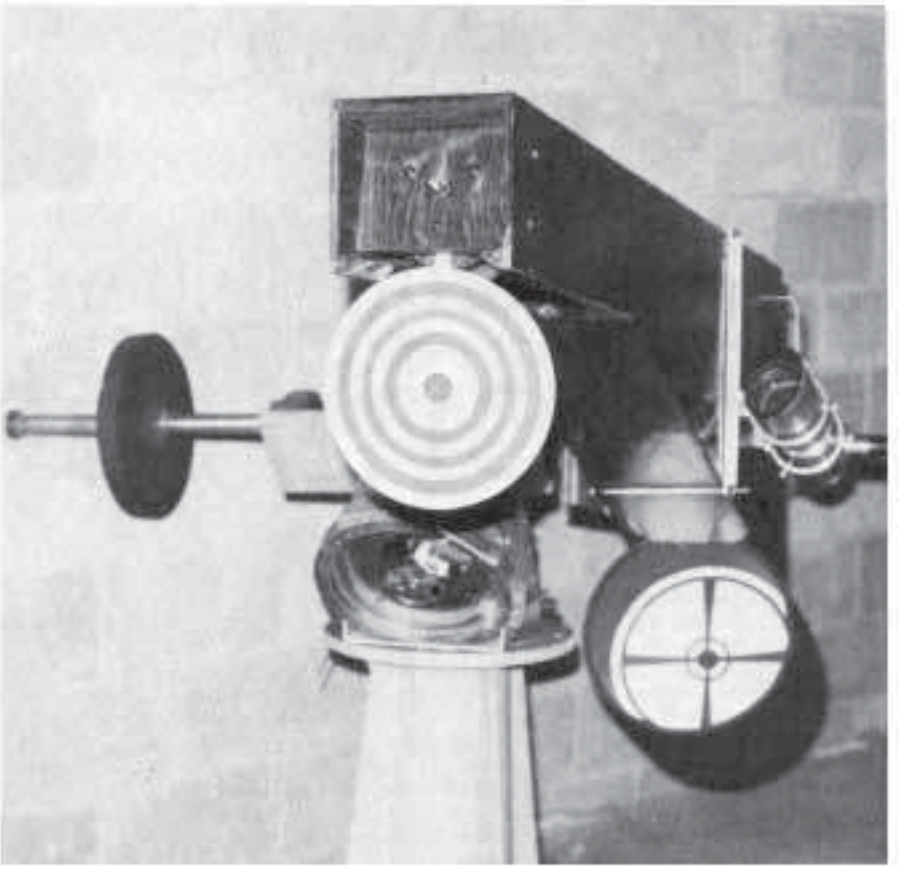
If you're building a first class instrument, it seems a shame not to go all the way and have both the mirrors coated for extra high reflectance and the lenses anti-reflection coated. It will make a difference on low-contrast details in planetary observing and is worth the investment for the serious observer.

Although the Schiefspiegler has been called a lunar, planetary, and double star instrument, if used in large apertures with long focus oculars such as a Giant Erfle or 2″ Plossl, it can also give magnificent views of deep-sky objects. In June of 1977, with 114

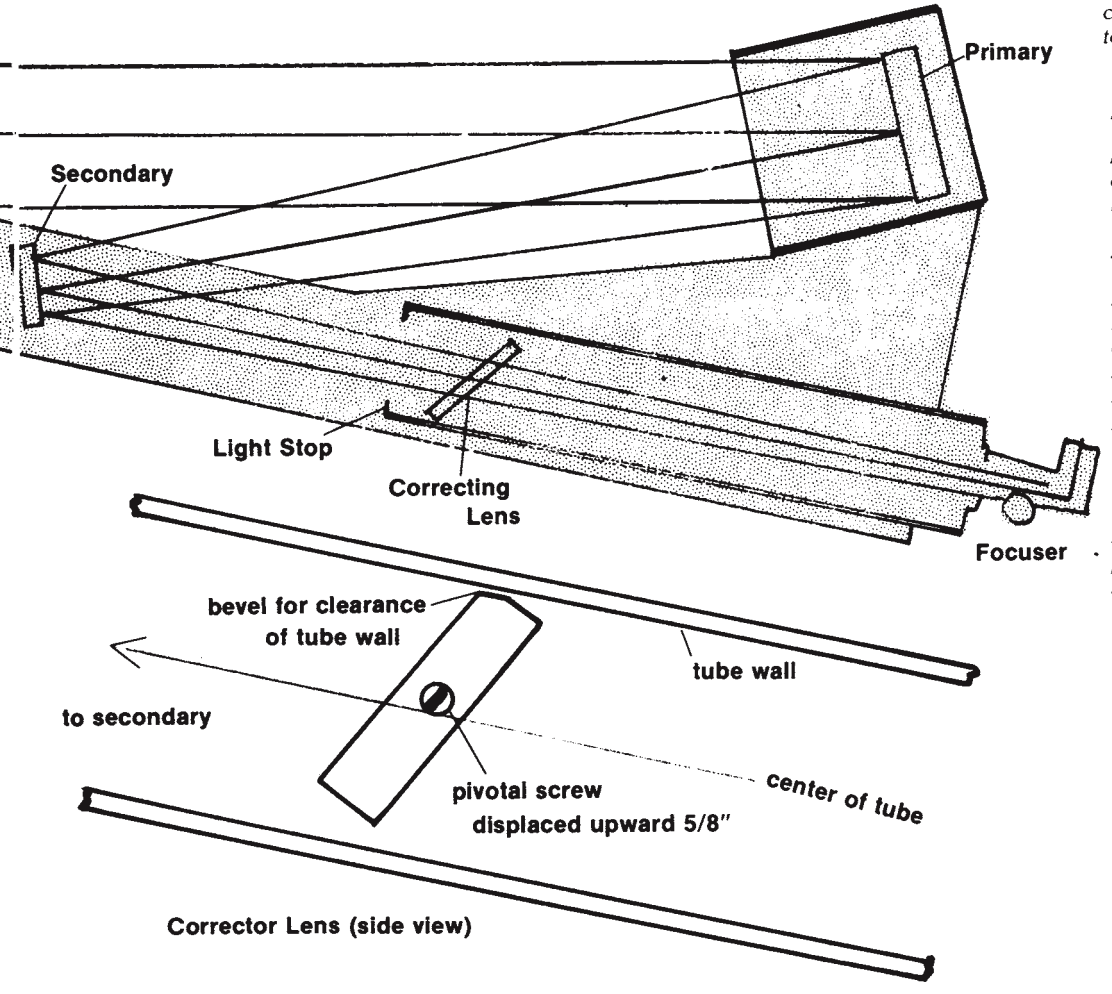
Dealing with the tilted focal plane...



This device slips over the outside of an eyepiece focusing tube (check the O.D. of your focuser just in case it's not the standard 1.312" size) and tilts the eyepiece the 6°45' required for best all-around performance. Machine the outer part first, then press-fit the tilt adaptor.



Alignment targets are necessary for accurate collimation. Both targets would not be used together at the same time.



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power and about a 2¼ millimeter exit pupil, the Pittsburgh team had M-13 and M-92 in Hercules resolved to their cores with views only comparing to the 13" Allegheny refractor.

Why the Schiefspiegler is more popular in Europe and not in the United States is hard to understand. It was introduced there by Anton Kutter but it has also been publicized in magazines in this country as well since 1957, and it is such a superior observing instrument. It seems to be a case similar to the use of the Barlow lens; it was popular and in use many years in Europe before it became a standard tool here.

After more than 45 years in astronomy and instrument-making and looking through all kinds of telescopes, amateur and professional, I have yet to find an instrument that performs better than a TCT for its aperture. Although it is awkward in appearance and (in large sizes) in handling, for the serious observer with an observatory it would seem the ideal telescope to own. I have followed the TCT in its development since 1952 and have material in German from Mr. Kutter which was published in European journals on his instrument. If anyone wishes to construct one of these instruments and has further questions on its fabrication and mounting, I will be only too pleased to assist them if they contact me at: 205 E. Elm St., O'Fallon, MO 63366.

Robert E. Cox

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An Amateur-Built Reflector with an 80cm f/2.4 Primary

by
Joseph G. Perry, Jr.

Every amateur hopes to have a large telescope complete with observatory. But the cost of such an ambitious project is usually the limiting factor and must be spread out over at least 10 years. My observatory project is now seven years old and is finally sufficiently complete that I expect to begin actual photon gathering in one or two more years. I've tried many ideas along the path, investing over 300 man-hours per year, but when I'm finished, my 80 cm (32") f/2.4/16 reflector will be capable of professional quality astronomical observations (including photometry and spectroscopy) as well as just plain viewing. I suspect that when it's done I'll have the largest and fastest primary mirror (80 cm and f/2.4) in the world owned and operated by amateur power. And if it turns out there is one bigger, then I'll just have to make a bigger one later.

Large telescope systems like this one must be carefully designed, fully blueprinted, modified as ideas are tried and tested, and built in stages, testing as the work progresses. It always seems that as soon as construction begins new and better ideas pop up. Take advantage of that and design your work flexibly.

Very early I decided to try a Dall-Kirkham optical system (ellipsoidal primary, spherical secondary) and later finish it to full Ritchey-Chretien (two hyperboloids) as my testing equipment got better and my "hands-on" knowledge of optical systems increased. I chose a standard fork design for the final mount (with one large 40" polar axis bearing), but I'm using a temporary alt-azimuth mounting for testing. Early on, I wanted a permanent site for my observatory, but I gave up and decided to put the whole system on a 21' flatbed trailer. The trailer will provide a lot of flexibilty; the front half will house all the accessories and observing controls, and the rear will be a fold-off type roof. Under it, the telescope will be mounted on skids that lift the whole telescope off the trailer hydraulically for observing and alignment. The trailer floor area will act as the observing floor.

The accessories I plan for include a 16" Schmidt camera, a 19" Schmidt spectrograph, photometry equipment, interchangeable f8/f16/f30 Cassegrain type secondaries, flip spider support so two secondaries can be pre-aligned, a 12.5" f/13 guide and flexure monitor telescope, a mini-computer controller, and hand-held walkie-talkie remote (wireless) controls.

To date, I've allotted the following amounts for necessary equipment and parts:

1) 80 cm mirror Duran 50 blank (precurved f/3) $1800.00
2) Miscellaneous secondaries and glass $ 500.00
3) Draper-type grinding/polishing machine $ 500.00
4) Pitch and grits and polishing agents $ 300.00
5) Coring motor and accessories for Draper $ 100.00
6) 21' flatbed trailer and welding machine $1100.00
7) Wooden testing mount $ 300.00
8) Initial aluminizing of 80 cm mirror $ 600.00
9) Aluminizing station with 16" bell jar $ 550.00
10) All-aluminum 36-point mirror cell, etc. $ 400.00
11) Miscellaneous anodizing and corrosion control $ 400.00
12) Surrurier truss hardware and spider supports $ 200.00

The author stands behind the grinding machine and distributes abrasive with a brush while the steel grinding tool carried back and forth by the traveling arm of the grinding machine does the work.

13) Steel fork mount and 40" bearing $1000.00
14) Miscellaneous hardware for mount, steel, hydraulics $ 500.00
15) Miscellaneous machine shop tools $1500.00

If that seems like a lot, remember that it's being spread out over a ten-year period.

Optical Fabrication

The Draper-type grinding machine I used was built in 1970 at the North American Rockwell Amateur Astronomy Club in Downey, California. Without it, I don't think I would have even been able to attempt a 32-incher. The machine's power comes from a 1.5 horse power motor with multiple V-belt pullies. It drives a single axis bar in an oval (elliptical) type stroke once each 4 seconds. (A straight type stroke would have been better, as I found out.) The main polishing tank rotates once in 60 seconds, allowing continuous polishing of mirrors while under a water/rouge solution.

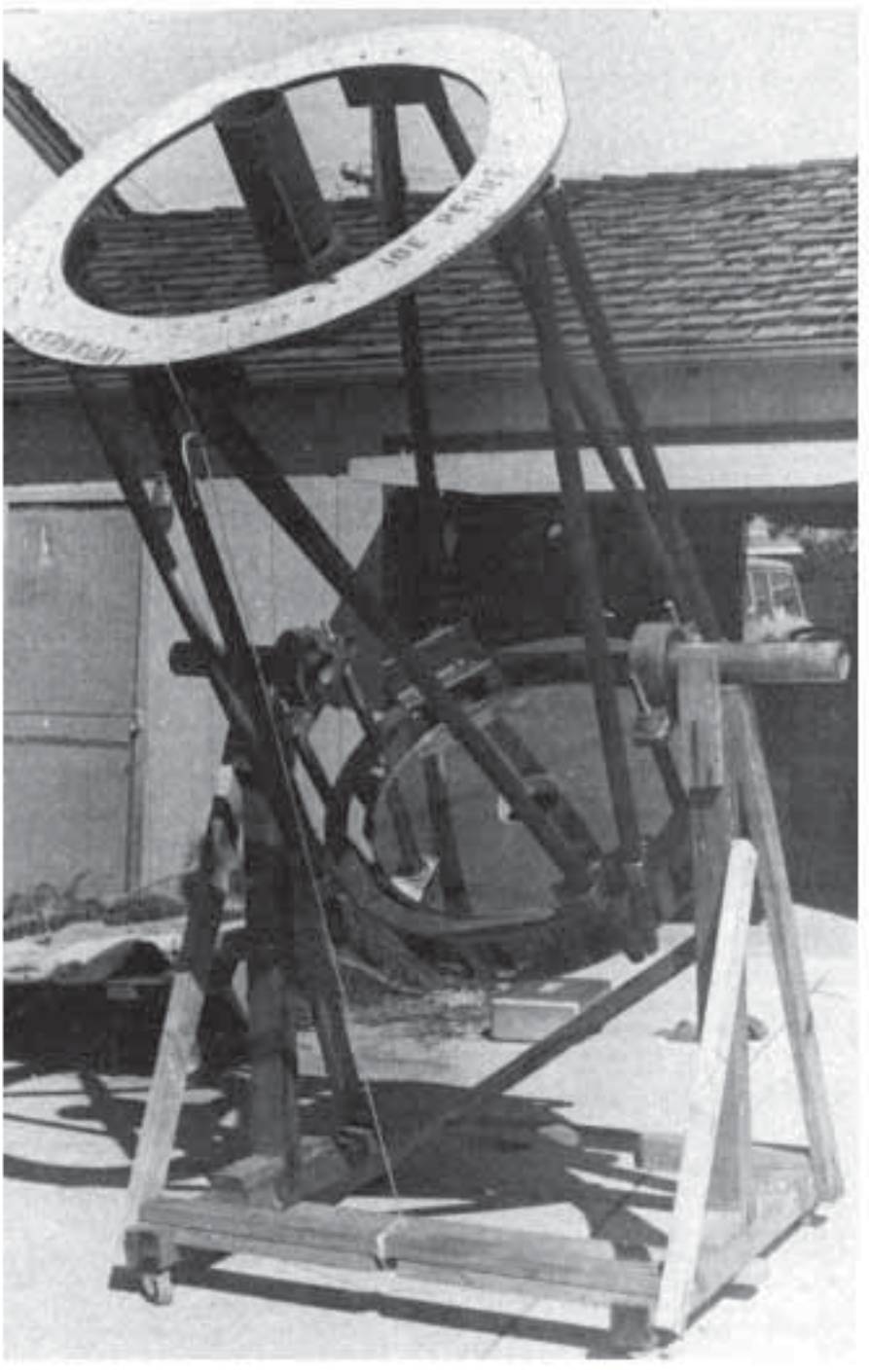
I went to Perkin-Elmer in Orange County and asked them how I could best support my mirror for fabrication, and they suggested that I core the mirror early and place it on a piece of carpet for grinding. They also advised that the carpet should be a type that wouldn't get hard when it got wet and then dried out. I obtained a piece of ½" felt and began grinding. The felt proved unsuitable, so I decided to try a passive 18-point mount since the final mirror would sit on 18 to 36 support points. The mirror kept itself in place by its own weight and needed no side restraints. I decided not to pre-core the mirror because I saw that all the grits would flow out the hole. The risk of breaking didn't bother me — if the mirror broke while coring after finishing the optical surface, then I'd have two large off-axis surfaces to make giant binoculars!

In buying the mirror blank, I saved some money by buying a mirror blank 27" in diameter and having it "squeezed" into my larger, thinner blank. At those sizes, you're buying glass by the cubic inch. I saved some effort, too, by getting it pre-shaped on the front to an f/3 curve. The blank is 3.5" thick at the edge, and the material is fine annealed Duran 50 (Schott's equivalent of Pyrex).

I don't think that the rather high thickness/diameter ratio of 1:10 is a problem at this size, providing you design the mirror cell correctly. One thing I didn't do was sandblast the backside to honeycomb the mirror into a lighter blank. It would be the overall best thing to do in any future designs.

The mirror weighs 150 pounds and you need a lot of horsepower to push something like that around, so I ground from 80 grit to 600 grit with the mirror face up, using a 14" diameter curved steel tool purchased from Coburn Optical Equipment, Long Beach, California. Actual grinding consumed 180 hours from roughing through 600 grit.

Throughout grinding, I used a 12" spherometer to take zonal radius-of-curvature readings across the mirror. By spending 60% of the grinding time inside the 70% zone I was able, while continuously deepening the mirror, to hold the figure spherical. I was not really interested in holding to any specific f/number; I just wanted to keep the surface spherical.



The telescope on its test mounting. Note the unusually short tube length resulting from the extremely fast primary. This mounting is temporary, but it allows preliminary testing of the optical system and mechanical structure.

Total Grinding Hour Breakdown

80 Grit	71 Hours	280 Grit	23 Hours
120 Grit	7 Hours	400 Grit	11 Hours
180 Grit	10 Hours	500 Grit	35 Hours
220 Grit	10 Hours	600 Grit	12 Hours

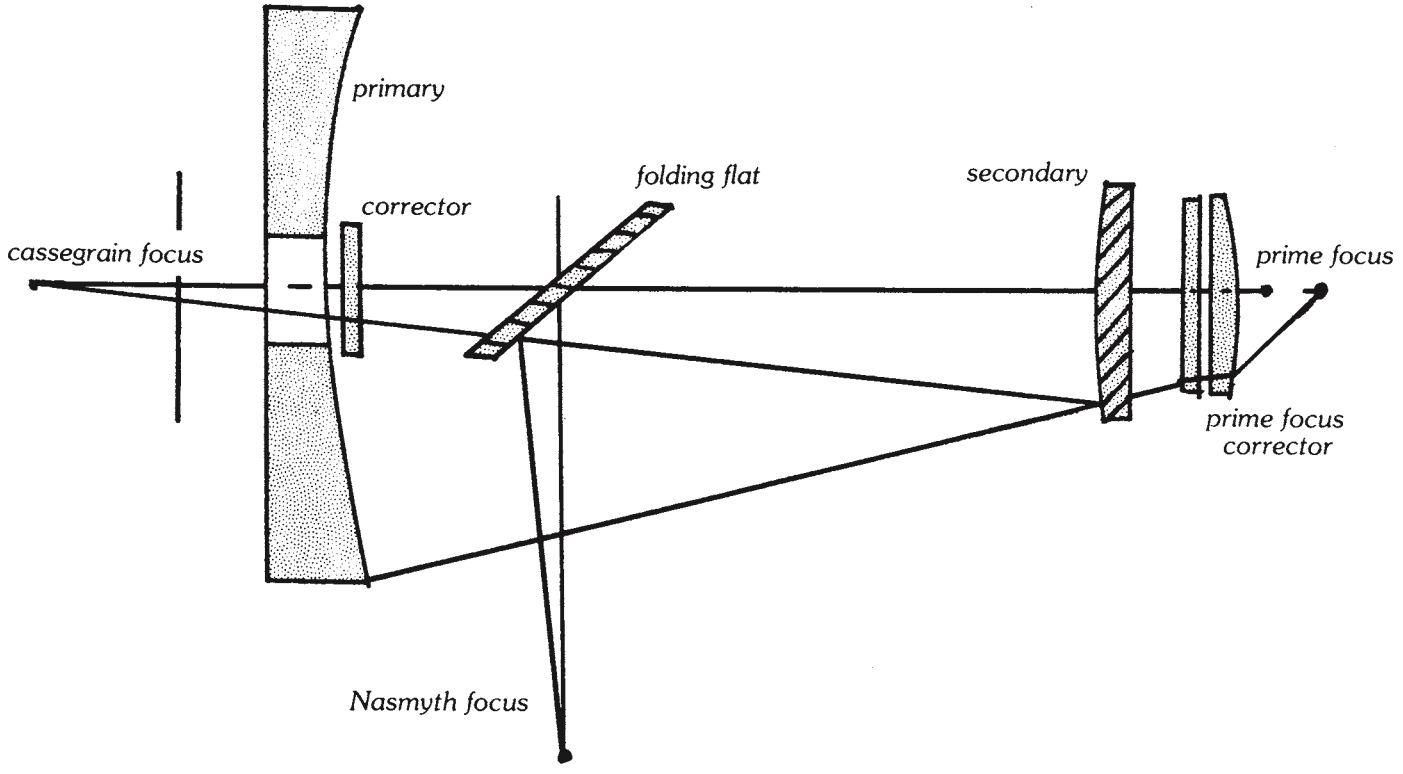
Total - 180 Hours

Grinding ended abruptly. While finishing off the #600 grit, I accidentally dropped the steel grinding tool on the cement floor. It was warped so badly that I couldn't continue grinding, so I was obliged to polish directly from a #600 ground surface.

Polishing

The oval stroke of the Draper machine made for interesting effects on the mirror surface. The pattern was not random and required changing the stroke every ½ hour or so to keep from ring zoning the mirror. The Duran 50 glass polishes very easily. I managed to not chip or flake the mirror's edges during all fabrication. Sleeks and scratches are practically nonexistent. At the end of figuring the Dall-Kirkham ellipsoid, there were a few 400 pits left (after 200 hours of polishing!). I estimate 200 more hours will be needed to finish the mirror to the Ritchey-Chretien hyperboloid, and they may polish out.

I started pre-polishing with cerium oxide,



80 cm f/2.4

probably the worst polishing agent ever invented. After 50 hours, I added some Barnesite to the mixture and did 60 hours more. I then proceeded into rouge for the 70 hours of polishing and figuring.

I had trouble keeping the mirror from heating up during polishing. Again I worked most of the strokes so that the polishing tool just touched the mirror's edge. This prevented a turned edge, but slowed overall polishing. The edge probably only has accumulated 50 hours of polish as compared to the 200 hours the inner zones got.

The sagital drop for this mirror is about 0.850". This is a very large depth to figure into a paraboloidal surface. To make the initial optical system easier, I chose a Dall-Kirkham ellipsoidal primary (83% of parabolic) for the first optical surfaces in part for simplicity; the primary could be null tested. I completed the system by null figuring a spherical secondary. It turns out that the f/2.4 primary is too fast to make a good Dall-Kirkham (more about that later), so after my system is working, I will continue onward to the true Ritchey-Chretien (107% of parabolic).

Coring the 6" Hole

I cored the mirror about halfway through polishing and figuring. How do you choose a core hole size for large mirrors? Well, I calculated ratios for several of the large professional telescopes and the hole came out 6" across for my mirror. The 6" hole turns out to be a ½° full field of view — enough for the Moon at f/16.

Grinding the 6" hole through the mirror took about 25 hours. I used a 6" thinwall steel

Optical Analysis

In this section I take a look at the optical performance of a single f/2.4 mirror with spherical, Dall, Cassegrainian, and Ritchey-Chretien surfaces used at prime focus, then at two-mirror systems, to compare the image spot sizes.

A multitude of optical surfaces will give images, but you need a sophisticated computer program to analyze a mirror system in detail. I have used ACCOS-5®, a trademark of National CSS, Inc., Connecticut, U.S.A.

I calculated various spot diagrams for on-axis and 0.25° off-axis conic mirrors. Each shows the image at best focus. Figure 1 shows the spherical mirror 0.83 (r2/2R) Dall-Kirkham ellipsoid, paraboloid 1.07 (r2/2R) Ritchey-Chretien conic sections.

You see immediately that the f/2.4 spherical mirror is very bad. The classic concentric rings of spherical aberration are easily seen (see figure 1, a and b).

Somewhat better is the Dall-Kirkham. Performing alone, the ellipsoidal mirror is, in fact, about five times better than spherical. But there is still heavy spherical aberration and some astigmatism off-axis (see figure 2, a and b).

One can't compare the paraboloid, since it's supposed to be a perfect diffraction spot on-axis. Off-axis, you get somewhat pure coma aberration (see figure 3, a and b).

So, onto the typical hyperbolic primary (figure 4, a and b). These are fairly nice images, about twice as good as the Dall-Kirkham, as indeed you would expect from a mirror departing roughly half as much from a paraboloid as the D-K. One sees the combined effects of spherical, coma and astigmatism (oval image) in figure 4 (b) for off-axis Ritchey-Chretien mirrors.

Two-mirror optical systems are quite sensitive to alignment, tilts, mirror figure, and spacings. I investigated this sensitivity for my Dall-Kirkham system in figures 5, 6, and 7. The Dall-Kirkham has a spherical secondary. If the known primary conic (0.83303) is off by only plus or minus 0.0010, the final on-axis images will be ten times larger at the second focus, figure 5.

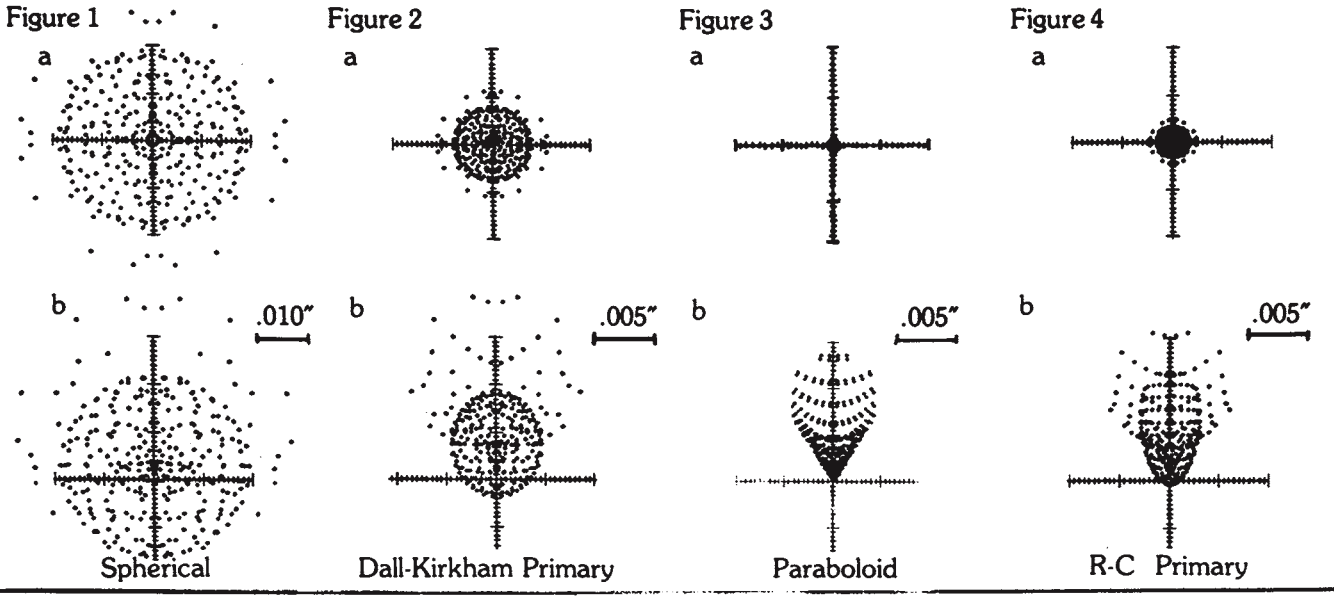
If you make a mistake in placing the secondary vertex with respect to the primary vertex, you find from the plot of image size versus vertex error in figure 6, a sensitivity of plus or minus 0.3" before the spot image doubles in diameter. In figure 7, you see an expansion of the rather broad minimum for secondary to primary separation.

The on and off-axis image quality is shown for my Dall-Kirkham system in figure 8(a), on-axis, and 8(b), 0.25° off-axis. Off-axis, the coma really shows up, making this system very poor for wide field uses.

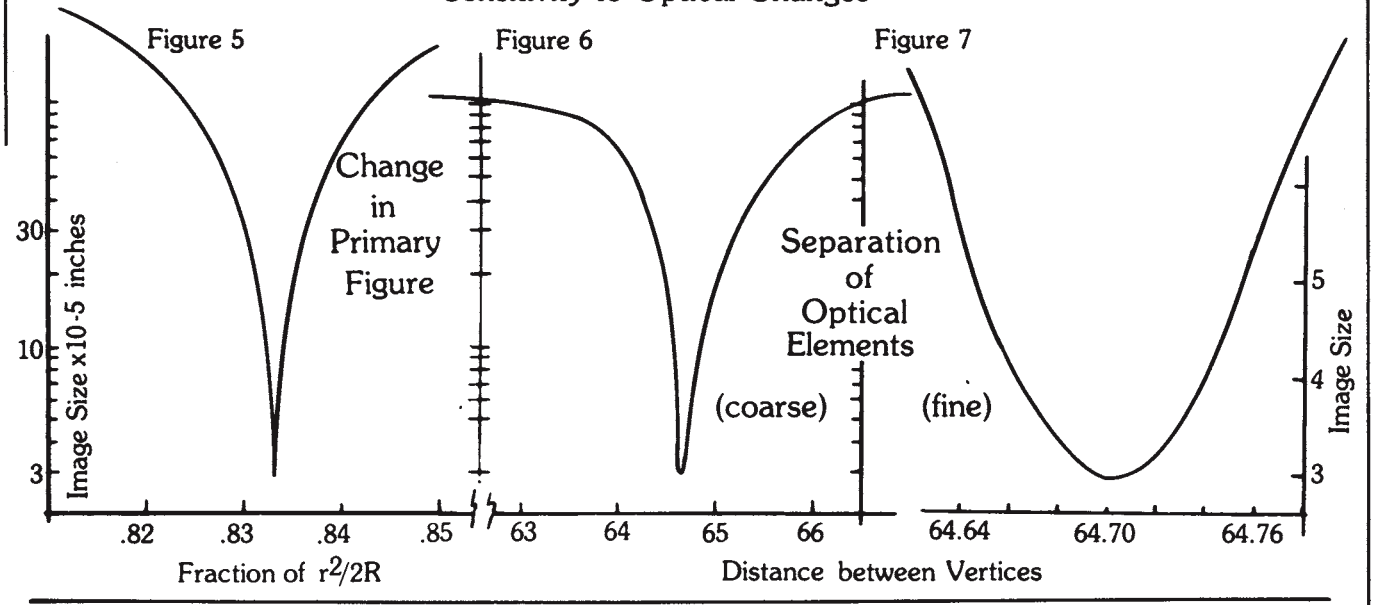
The classic Cassegrain is very nice for some uses in astronomy and has much reduced aberrations compared to a Dall-Kirkham. Without other elements, it can't be fully corrected for its coma aberration (figure 9,b).

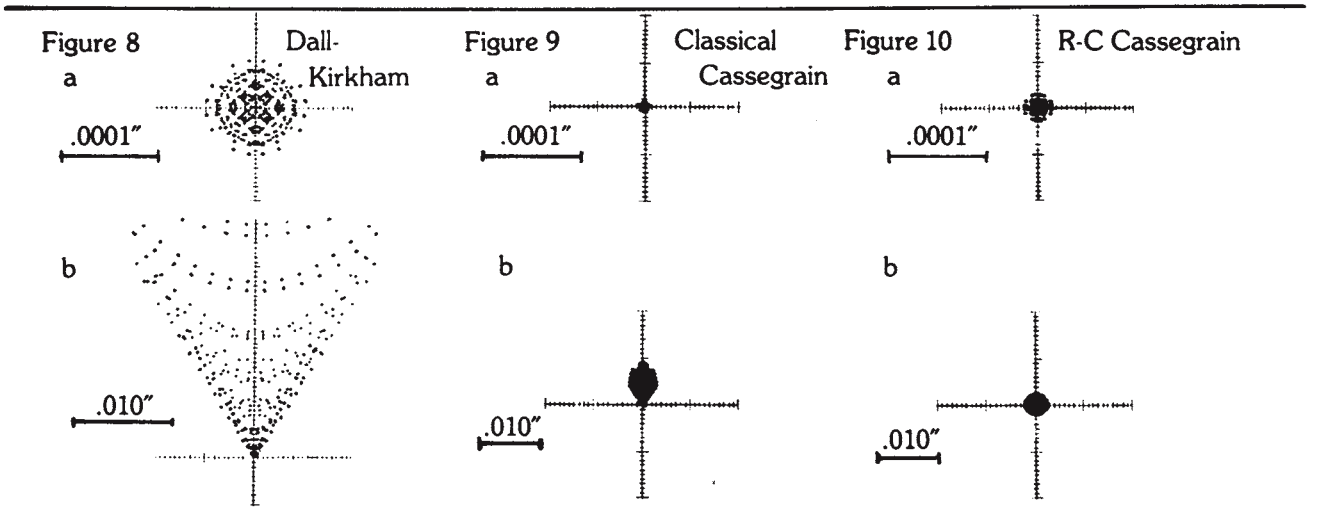
In comparison, the images of the Ritchey-Chretien, shown in figure 10 (a and b) are better by an order of magnitude than the Dall-Kirkham. The images are comparable to Cassegrain but better compensated for off-axis imagery.

OPTICAL PERFORMANCE



Sensitivity to Optical Changes



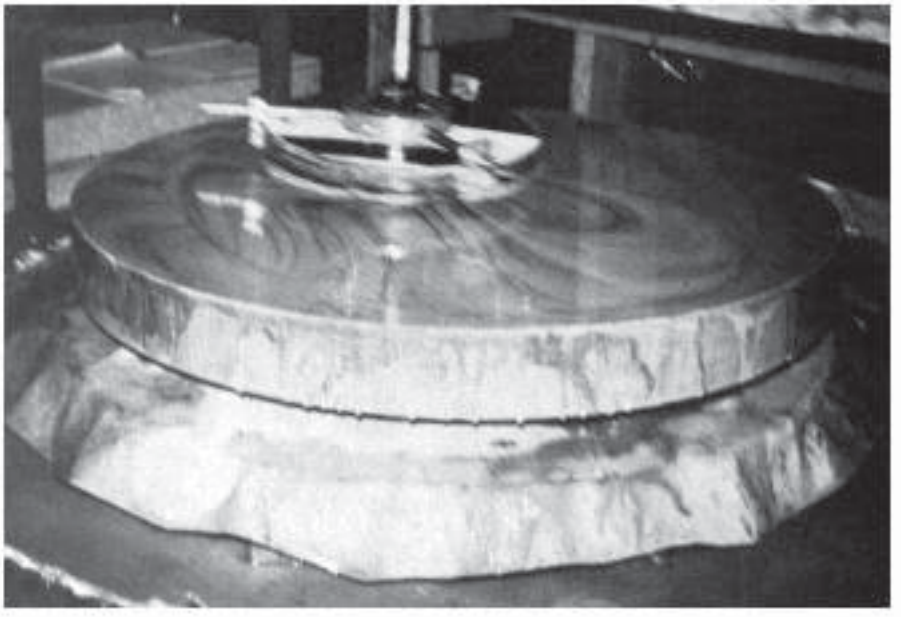


On-Axis and Off-Axis Image Quality for Different Optical Systems

80 cm f/2.4

tube, #80 grit, and a low speed motor to rotate the tube. The device was centered over the mirror and allowed to grind through by its own weight. I began the coring from the mirror backside, and when the core tube had just broken through to the front, it seized. I had to use my car jack to pry the tube out of the hole. (My big mistake was not providing sufficient protection between the mirror surface and the 18-point suspension I polished it on. As it happened, the mirror ended up with some short dig scratches due to movement during coring.) I then placed the mirror face up and finished coring from the front; later I bevelled the core edges to relieve any microstress.

The 32" mirror during polishing. Note the space underneath the mirror; this is the height of the 18-point flotation system.



Figuring to the Dall-Kirkham

I was delighted to find the primary mirror almost a spherical surface after sufficient polishing to begin Foucault testing. It's very hard, however, to read the outer three inches of a mirror as big and fast as an 80 cm f/2.4 with the knife-edge test. Zones from center out to the 75% zone are quite easy; the shadows are very strong and well-separated.

I decided to figure the mirror by deepening all zones from the edge inward to the center. I started using the classical methods, but the old-fashioned "W" stroke, with a mirror face up, does not apply the same differential pressures to the mirror surface as it does face down. If the mirror is cored, for example, all the polishing agent runs out through the hole and every time the pitch lap tries to go by the hole, it wobbles. I abandoned the "W" stroke.

I began short oval strokes with a 10" lap, where the stroke goes back and forth on just one side of the mirror. The center of the tool would travel about 12" out and back with the width of the oval traveling about 3" to the left and about 3" to the right of center line for the zone being worked. This made the the mirror zone very easily. I would get a high ridge on both sides of the oval stroke, and a depressed zone in the middle. So I tried increasing and decreasing the zone radius at which I was working to push the "ridge" areas further up the surface. I moved a lot of glass around, back and forth, zone to zone and got nowhere with figuring by zonal deepening.

I thought the 10" lap might be too small or too big, so I tried a larger lap and found I could not push the glass around on the surface well enough to establish a figure either. I went to a 6" lap next and tried the same thing and got smaller deep zones. This helped, and by spending many more hours deepening the inner zones and then going to the larger lap to smooth off the top of the high ridges, I was able to push the glass down to a figure. I really had to over-figure each zone area to allow for fill-in by the smoothing lap.

Some of the problems I encountered were certainly due to the oval stroke. As I said earlier, I would recommend that all polishing machines have straight stroke capability.

I managed, through all this polishing and figuring (face up, no less!), not to scratch or sleek the mirror. The only scratches were due to the coring exercise when the mirror was sitting face down on the 18-point support system. The mirror slid about ½", and so there are about 18 short digs where the support points touched.

Testing

I used every test in the book that didn't require expensive equipment. I used the Foucault test to rough in the zones, but Foucault testing an f/2.4 mirror is very difficult. I tried wires, razor blade edges, slits and pin holes. I also used the Caustic test in the later stages.

Then I tried the two-focus null test. It worked. (See TM1, page 10, fig. 3 for a diagram of this test.) It required 150' of open air space, and after coring, aligning the mirror and light source proved very difficult, because it seemed any tiny skew in the mirror optical axis causes severely astigmatic images at the second focus. Basically, though, the two-focus null test worked very well. I'm sorry that I didn't take "focogram" pictures as I went along.

Another worry was coring the mirror: Would it cause a figure change? Afterwards I was relieved to see some release of the glass's strain around the core hole edge, but no changes across the rest of the mirror. Figuring became more difficult though: it was impossible to keep from turning down the core hole edge in a zone about ¼" wide. I attempted to be very careful with the outer edge, and only the very outer 1/16" around the edge is badly turned. At this time, I haven't put the final bevel on the mirror, but after the final Ritchey-Chretien figuring, I'll remove enough glass to eliminate the turned edges.

Overall, I wanted to achieve the proper zonal depths — at least roughly — and end up with a smooth surface. If I didn't get exactly the right figure on the primary, I was willing to design a secondary of proper conic to null the total system. I regret having stopped at 83% parabola — the total Dall-Kirkham system is optically useless with large apertures and a fast primary except, perhaps, for photometry and spectroscopy.

The Mirror Cell

For testing the telescope, I designed an all wood mirror cell, with 18-point floating back support, and 6-point edge support. This mount allowed outside null testing and star testing of the optics. The first major problem I'd encountered became evident at this time: I had 4 images at prime focus. The mirror, when sitting on edge, was "potato chipping."

Clearly, the mirror cell had to be redesigned. My initial cell's 18-point back support, which worked on the rocker arm principle, and 6-point edge support (points also on rockers), was not doing the job. The mirror warped badly when inclined to the horizon, unusually flexible because of its 1/10 thickness/diameter ratio. "Potato chip" is something of an exaggeration, but that's the basic shape of the distortion.

So I went to 36-point back support and tried supporting the edge uniformly with inflatable rubber hoses. The hose went completely around the mirror perimeter and was filled with heavy oil. This idea helped keep the mirror from falling away from the back supports when inclined, but also added differential friction pressures. There were still two images at prime focus.

I now have gone to 50 small spring-loaded Teflon balls. I can adjust the internal spring pressures of each ball and have very little friction against the mirror's edge. The mirror now floats on 36 back pads, but its edge is defined so that the optical axis does not tilt or

Above: At long last the mirror is aluminized! Note the coating tank in the background, with diffusion pumps for high vacuum. Right: The 36-point flotation mirror cell shortly after fabrication.

translate. An aluminum edge band holds the edge supports and the 36 passive rocker points.

The rest of the finished instrument is still in the planning or early fabrication stages. It's ambitious, but practical.

The entire system will be housed on half of a 21' flatbed trailer. The fork mount will be a welded steel truss mounted to a 40" diameter precision bearing. The declination axis will be standard 10" roller bearings. I hope to use one side of the declination axis for viewing. The Surrurier truss is heavy wall tube held by speed-rail fittings.

The whole system is completely adjustable for any future changes, and I anticipate plenty of them in the next few years as the system comes together. After all the gasoline is gone, the smog will lift and the streetlights can be shut off, and we'll all see the sky again.

I must thank the past members of the North American Rockwell Astronomy Society, especially, Stan Truit, Bob Haney, Alex Kiss, Manny Machado, Brian O'Connell, Jim Kissick and more for giving me the time, place, and enthusiasm to undertake this project.

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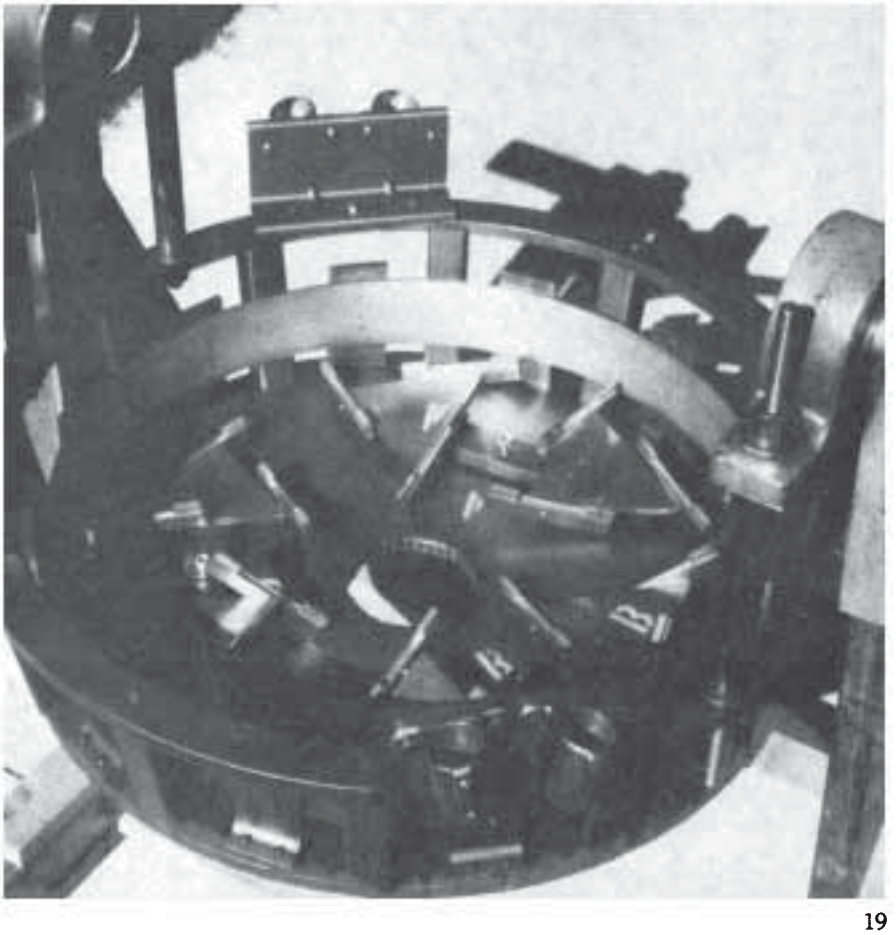
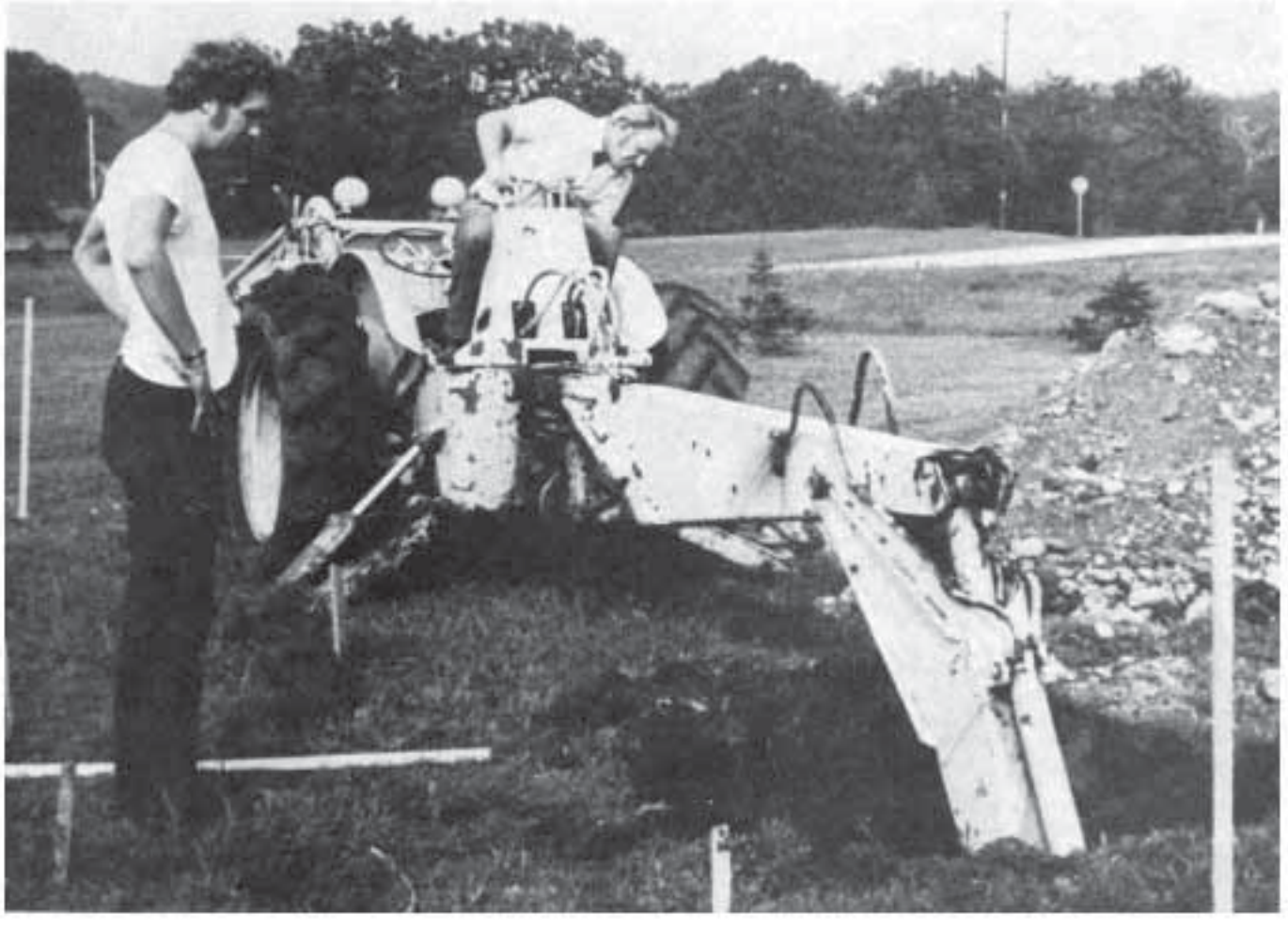


SCUPPERNONG OBSERVATORY

by
Thomas Renner



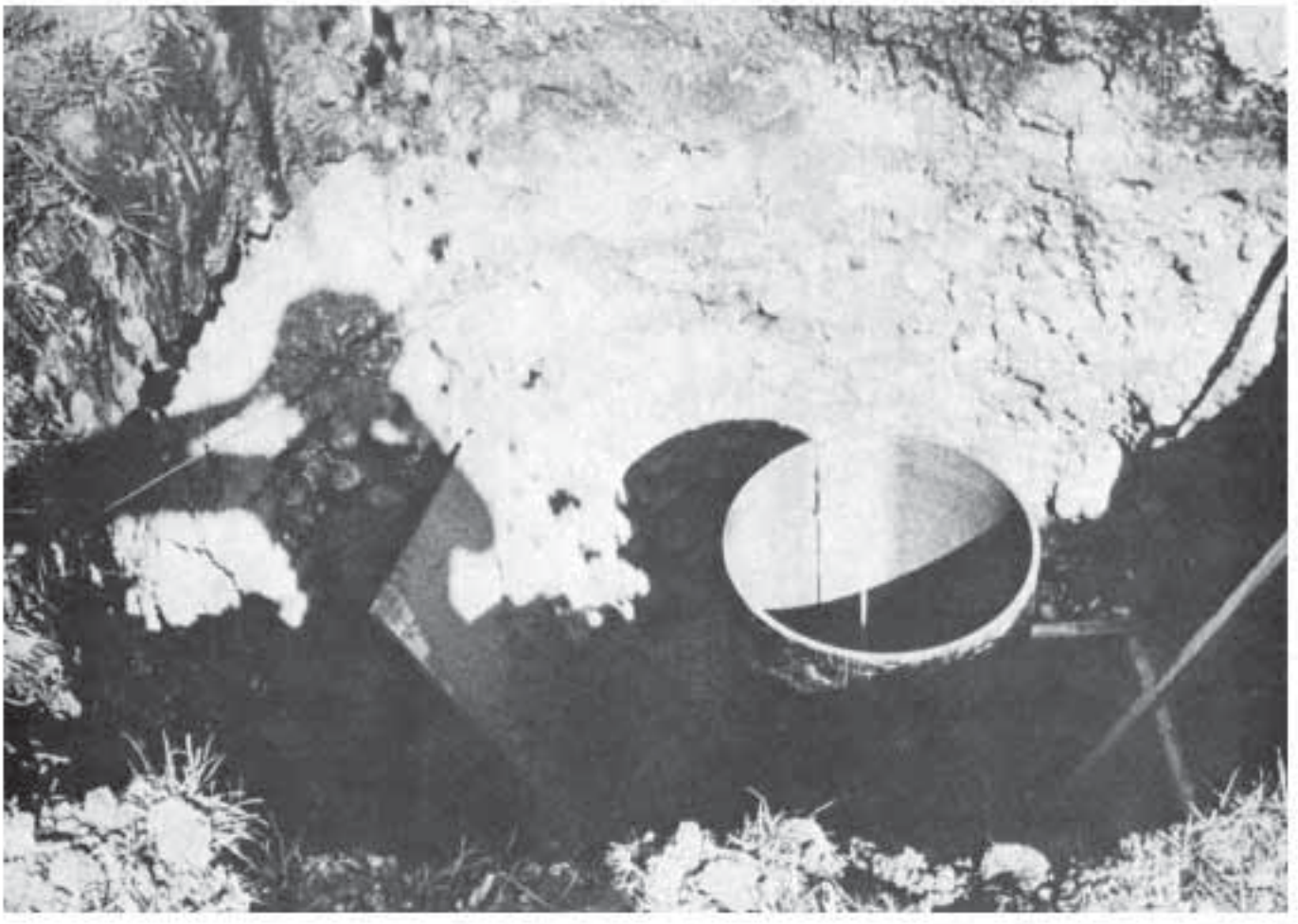
Scuppernong Observatory was a project born out of necessity: our homesite in the outlying community of Dousman, Wisconsin is totally exposed to the cold northwest winds prevalent from October through March. Serious outdoor observing in these months is impossible. Therefore, in September of 1975, I broke the ground for a 14′ diameter domed observatory.

The observatory building is octagonal. Each corner rests on a 6″ diameter concrete post formed out of sonotubes extending about 5′ deep to penetrate below the frost line. In many areas the posts could have been installed with a powered post-hole digger, but our area consists of glacial deposits of stone and gravel, so I had to hire a local contractor to excavate the footings with a backhoe.

The observatory floor is 5/8″ plywood nailed to a conventional floor joist system of 2 x 10s obtained from a home being demolished in Milwaukee. Above grade, each corner post consists of two 2 x 6s nailed together and bolted to the concrete posts. The corner posts were capped with a 2 x 6 nailed flat, connecting each post and forming the top ledge of the walls. The corner posts are 5′ high, which results in a 4′ wall inside.

The observatory exterior was finished in vertical rough-sawn wood siding, stained to match our home.

The dome rides on 8 adjustable roller assemblies, each resting on a corner post.

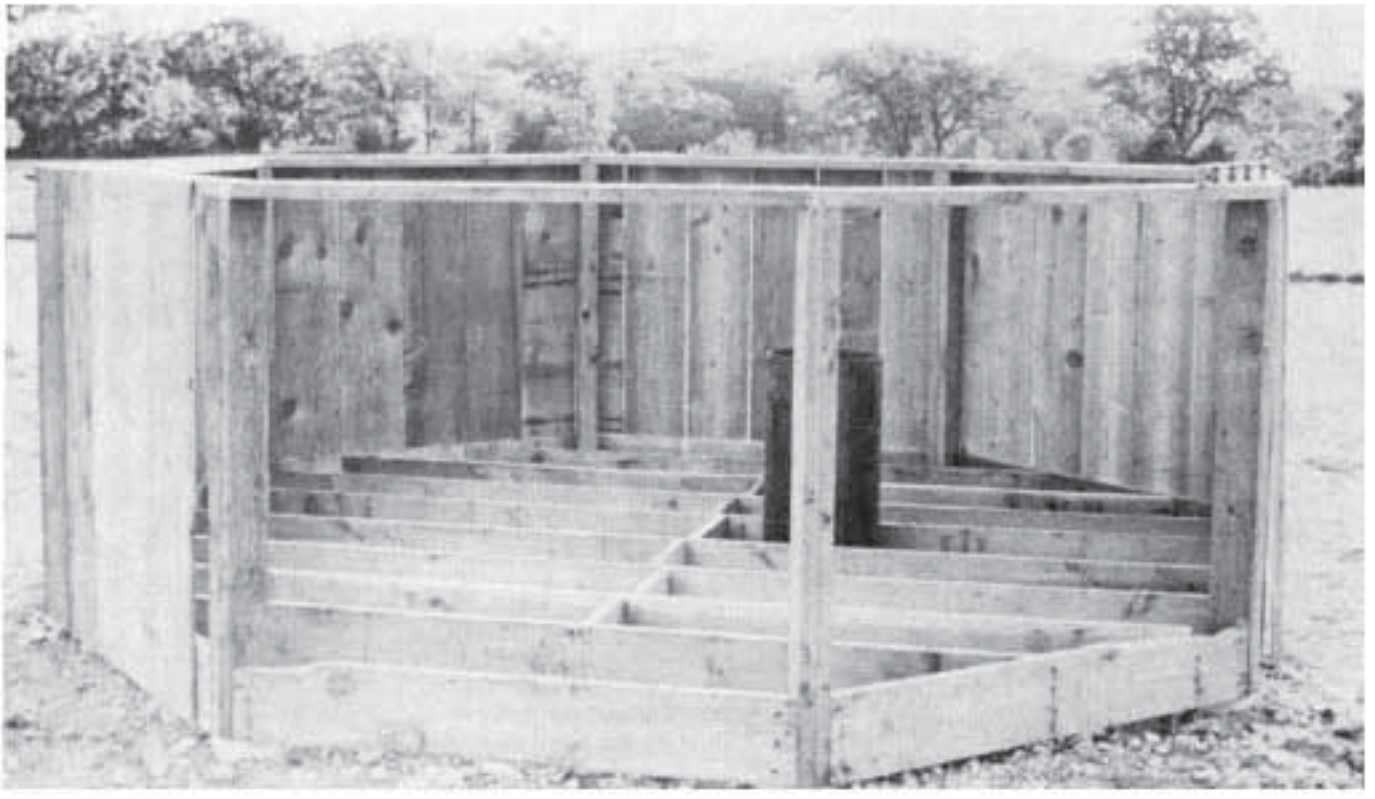


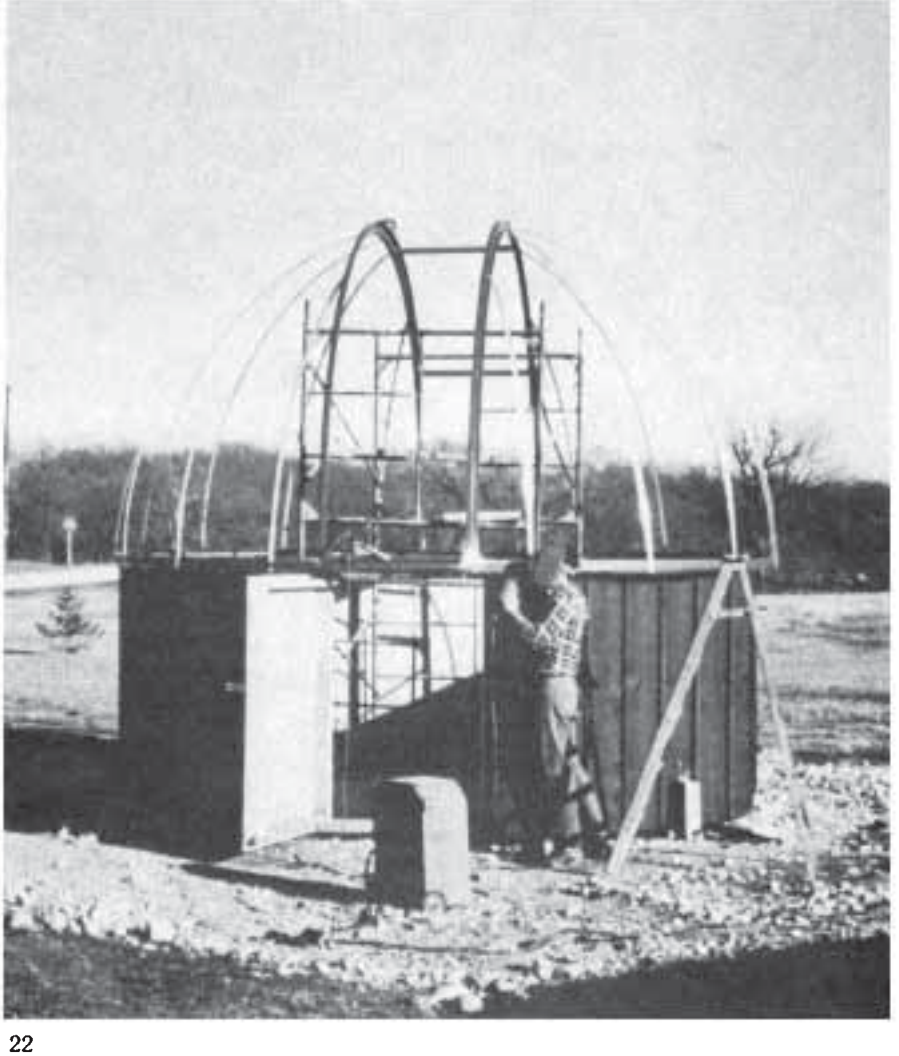
Left: Mr. Renner watches while the backhoe operator digs the hole for the telescope pier in rocky Wisconsin soil. Above: The telescope pier is made of 16" diameter steel pipe cast into a heavy concrete base. It extends 5' into the ground. Right: Welding the first crossbraces into the observing slit frame with a borrowed welder.

Initially, the roller assemblies were made of roller skate wheels, but their ¼" axle shafts quickly failed and had to be replaced. The new assemblies consist of inexpensive roller bearings riding on shafts of ½" threaded rod. These have proven very satisfactory, with no problems since.

The base ring is made of three lengths of 2" x 2½" x 3/16" angle iron. The angles were rolled to a 14'3" diameter at a local job shop, at a cost of $13.00 each. Since the ends of each piece rolled to a radius will end up straight, make allowance for the waste material in advance. After cutting off the ends, I positioned the angles on the roller assemblies and welded them in place with a small borrowed arc welder. The base ring angle was selected to have some "give" to it, to allow it (and the entire dome) to deflect, rather than bind, if it should be slightly out-of-round. This decision has proven to be a good one; the dome can easily be turned with one hand at all times — even at below-zero temperatures.

The observing slit frame consists of 1½" x 1½" x ⅛" steel angle iron, rolled to the same





Above: The walls of the observatory are not high; this permits a low pier and comfortable observing heights. Note the conventionally framed wood floor and walls, and eccentric position of the pier. Left: The dome takes shape as lightweight aluminum bars are added. Welder is working on the dome slot track. Right: Attaching the skin involved riviting light aluminum panels. The man inside the dome holds a stick to prevent buckling the thin metal. Far right and below: The 10" telescope mounted in the dome; first snows.

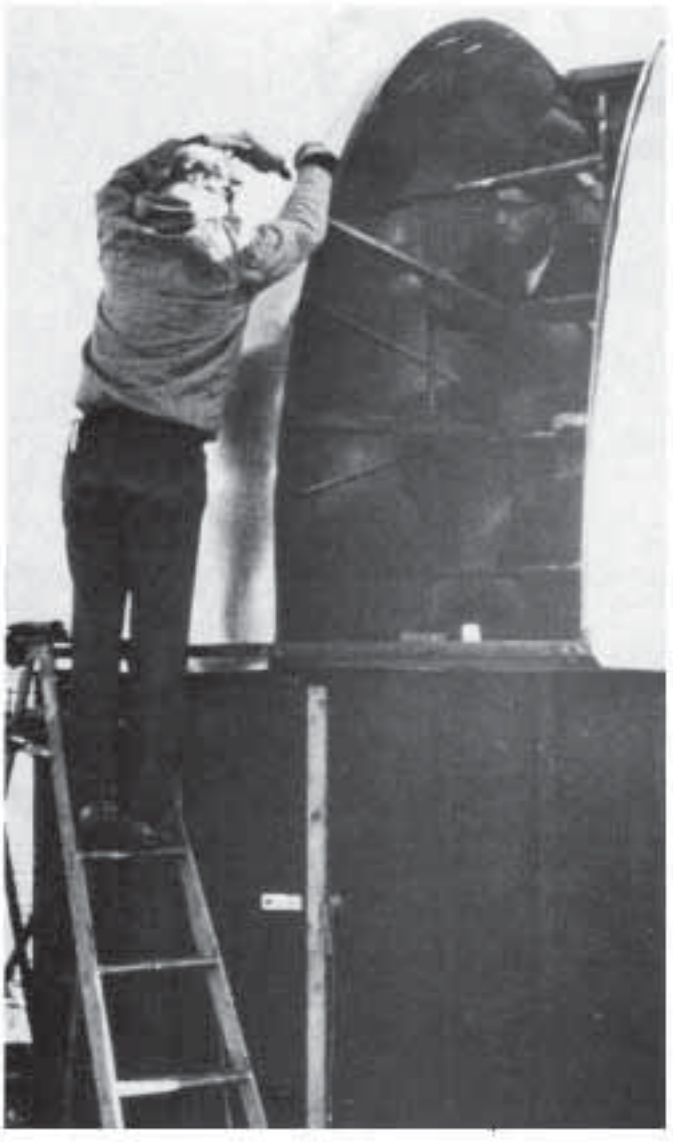
scuppernong

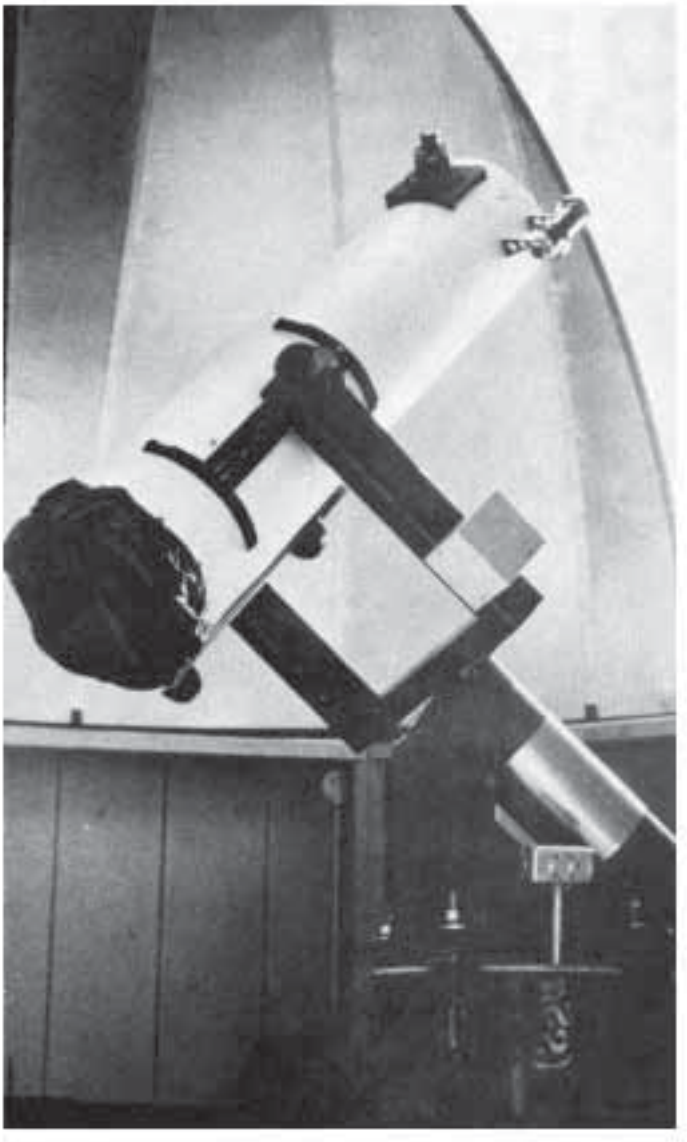
diameter as the base ring. These were welded to the base ring and form the only rigid frame for the dome skin. Similar sized angles were welded in place to serve as tracks for the shutter assembly.

The dome "skin" is 0.025" thick sheet aluminum cut from 3' x 10' sheets. Each sheet was cut to size and pop-riveted to a rib of ⅛" x 1" aluminum bar stock, which serves as a rigid backing for the rivets. Except for the shutter frame, the dome skin is entirely self-supporting, resulting in a lightweight but strong unit. I caulked the seams with clear silicone sealant, and the outside seam was covered with another ⅛" x 1" aluminum strip to give a finished appearance.

In retrospect, I should have used an opaque sealant. Why? Direct sunlight tends to shine through the clear sealant in the joints, giving the distressing impression that the dome would leak! But it doesn't.

The shutter is made in one piece to minimize the number of cracks to weather-seal. It rolls to one side on four grooved conveyor pulley wheels which ride on angle iron tracks. Like others before me, I found it necessary to use a cable system to pull the top





of the shutter open and closed as the bottom is directed. 1/16" stainless steel aircraft cable works well.

Electric power was brought out from the house in buried conduit to power the telescope drives, the electronics of my photoelectric photometer, and a desk lamp.

The telescope pier is made of two scrap pieces of 16" diameter steel pipe welded together, and anchored in a base slab of concrete 3' square buried 5' down. I will be the first to admit that the pier is oversized, but the pipe was free, and it's rock steady! Since my home-built 10" reflector is fork mounted, I offset the pier south of the center of the dome, so that the declination axis of the scope is on the centerline of the observatory.

Due to unseasonably warm weather in the late fall, I was able to complete the project and start observing by January 1, 1976. After 4 months of part-time construction, at last, with my own observatory, the cold north wind no longer prevents me from observing on any clear night!

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Riverside '79

Riverside-a personal memoir

by Richard Berry

The eleventh annual Riverside Telescope Makers' Conference was held on Memorial Day weekend at Camp Oakes, near Big Bear City, California. Those 700 telescope makers who attended — despite the difficulty of obtaining gasoline in southern California — were rewarded with three clear nights and four sunny days for enjoying the camraderie of astronomical pursuits. It was, in short, nothing less than a wonderful meeting.

I arrived via Hughes Airwest early Friday afternoon, rented a car, and drove off down I-10 toward San Bernardino, stopped for a frozen yogurt topped with hot carob (my favorite and hard to get in Milwaukee), then drove on up route #330 into the San Bernardino mountains to Running Springs, and then along #18 to Big Bear. (Driving into the mountains may be commonplace for Californians, but to me, raised on the curvaceous Appalachians, it was a succession of postcard scenes turned into reality.) As the road climbs into the mountains, you find yourself driving a two-lane two-thirds of the way up, with 60-degree slopes on both sides. Big Bear Lake and the surrounding area seems to specialize in boating and skiing, and reminded me of Virginia Beach (chalet style) transplanted to 6000 feet. Five miles past Big Bear City, on route #38, the Lake Williams Estates turnoff leads, via a circuitous route, into Camp Oakes.

Camp Oakes is a YMCA campground nestled down in a mixed grove of oaks and conifers. Those unable to bring tents or RVs — like me — could bed down in a reasonably comfortable dormitory for $21 (which included, by the way, five meals); those able to feed and shelter themselves paid a very low registration fee of $1.50 per person (that's too low for what you get). The registration tent at the entrance was within sight of a few telescopes, so I knew I'd arrived.

There were telescopes set up everywhere in the campsite, down near the lake and back in a lightly wooded area on the far side of the meeting hall, but mostly on the central "parade ground." If you're a dedicated telescope maker, the first sight of that area is a little piece of heaven: even on Friday afternoon, the day before the meeting officially began, there were at least a dozen telescopes including Mike Hatcher's huge grey 22″ alt-az as a centerpiece. This instrument is mounted on a massive plywood carriage that turns in azimuth on hard rubber wheels; in altitude it moves on large trunnions. It takes a hefty push to move it, but it's a very steady mount. Certainly whatever it lacks in polish it makes up in performance.

By dusk, twice as many had arrived, and the greetings, gatherings, and conversations that would last the whole weekend were well underway. I went into town at dusk with Ben Mayer for a good German restaurant meal (I met Ben last year at Stellafane) and came back to put in about four hours of observing on that marvelous 22-incher. Under the clear skies of Camp Oakes (and even under partial cloud cover that mysteriously appeared and disappeared throughout the night) I *really* saw M-51 for the first time. Now, I've looked at it before in telescopes hundreds of times, but never with such a big telescope under such excellent sky conditions. (Good skies with a little telescope and big telescopes under a bad sky don't add up to the same thing.) I think I could have hung on the eyepiece all night drinking it in. The arms were there, clearly visible; the companion was easy to see, even its irregularity was apparent; the tiny galactic nucleus showed up; and the knots and dark lanes in the arms were there — but description fails: you'd have to see it for yourself.

I wasn't counting them, but we did a lot of Messiers that evening even though the telescope had a collimation problem Mike couldn't track down until the next day. I wandered off to try other telescopes too, and took a look at the San Jose group's CID television camera. A CID is a solid-state imaging detector, a "TV camera on a chip." Its fourth magnitude detection capability (used on an 8-inch Celestron telescope) seemed pretty good for an off-the-shelf device costing about $1000. Saturn appeared as a green oval on the monitor. I listened to Pete Manly, who acts as a project coordinator for this group effort, describe all the technical details about integration times, the sweep circuits that cost $29 in parts, the difference between a CCD and a CID, and was, I think, most impressed with the documentation they've kept on the project. Right beside the CID camera system was Kevin Medlock's

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18" f/4.6 Newtonian reflector, a handsome-looking telescope that was a Merit Award winner in 1977. I never did get a chance to look through it (too busy yakking, I'm afraid!), but the clean lines and workmanship of this massive fork-mounted open tube instrument looked very good. The plaque on the side of the declination box carries thanks to seven individuals who helped in significant ways with the materials and construction of the instrument. That plaque, an eloquent gesture, seemed to epitomize the spirit of Riverside.

Saturday morning dawned bright and sunny, and after a hot shower and breakfast (crackers, currant jelly, and a Coke), I took in some of the scopes down by the lake. Particularly impressive was Arnold Schwartz's highly functional 8" f/6 on an all-wooden mount (see page 36). Up on the parade ground was a big Dobsonian telescope, "Das Edelweiss," a 16-incher painted bright yellow. I'd used it the night before, but the owner hadn't been around to talk to. It was the first of these instruments I'd ever seen in its natural setting (i.e., California), though I'd seen Dennis DiCicco's variant at Stellafane the year before and had subsequently remounted my own 12" similarly in anticipation of building a bigger one. The owner of "Das Edelweiss" turned out to be Doug Berger, of Comet K-B-M fame, and his telescope was the one that had inspired Dennis to build his. It felt odd standing there looking at the previously-unseen grandfather of the concept behind my own instrument.

These Dobsonians have a technical elegance about them that is extremely appealing, much more so to me personally than the austere splendor of an instrument created entirely in the machine-shop. I reflected on the subtle cross-pollination of ideas: the basic technology originating in the San Francisco Sidewalk Astronomers and somehow migrating down to the Los Angeles region, mixing with the indigenous stock, blending, mutating, traveling east to Boston with Dennis and then west again to Milwaukee with me. (The idea itself can, I suspect, be traced much further back.) Later in the afternoon Earl Watts and Bob Kestner arrived, the only emissaries from the gasless San Francisco group, bringing with them a beautifully-made dark blue Dobsonian. This instrument represents the state of the art in Dobsonians and is described on page *31*).

Later in the morning I met briefly with Pat Michaud, chairman of the Merit Awards committee, to discuss my duties as a member of the awards committee. Basically, awards are given for excellence — in design, craftsmanship, and concept. "Look for something that grabs you," he said — so I was to spend many hours during the next two days looking at the 40-some entries. There are two fixed awards: one, the Warren Estes Award given for the best use of simple materials; the other a Junior Award for young telescope makers. One thing I particularly appreciate is that all of the awards have equal value. There is no first, second, or third, but only recognition of talent or concept expressed in mechanical form. Such merit is a difficult thing to define, but it's recognizable on sight.

The Conference got underway at noon with the first official meal-ticket lunch followed by the opening paper session. Introductions by Robert Stephens, Phil Gilbert, and Ashley Thomas McDermot soon gave way to the first paper session. Since the conference proceedings will be published (and are available for $8 from Bill Schramm, 24151 Las Naranjas, Laguna Niguel, CA 92677), I won't discuss the papers here. In any case, because much of my time was devoted to looking at over 100 telescopes and inspecting carefully the 40-or-so Merit Award entrants, I didn't get to hear many of the papers.

Many people arrived Saturday afternoon swelling the number of telescopes and observers. As darkness fell, the observing rituals began, people crowding around the telescopes, especially those on the parade ground. The astrophotographers, anxious to be away from all lights and commotion, had set up in the open woodsy area just east of the parade ground. Walking down the little road that runs through that area, you could feel the intense concentration of observers guiding and hear tape decks whiling away the time. Amazingly, nobody played music obnoxiously loud, and the general sense of peace and calm

"Time for a group shot, yodellodellodelloeeeii," brought out quite a crowd, but nowhere near all the participants in this year's Conference. Cliff Holmes, right center wearing sunglasses and patch vest, Ashley McDermott with hand on Cliff's shoulder, and Robert Stephens, seated front row,far right with camera, were organizers.

was wonderful. Tea, coffee, donuts, a free movie (**20,000 Leagues Under the Sea**), and afterwards a laser light show were available in the meeting hall. I went to bed at about 4 a.m., cross-eyed and exhausted, but satisfied.

Sunday brought more talks, more telescope inspection, time for leisurely conversation, and a Swap Meet in the meeting hall. An enormous number of optical and astronomical items — eyepieces, camera lenses, mirrors, prisms, government surplus — were bought and sold, and for many it was a high point of the conference.

I'm no longer sure whether it was Sunday, although I think it was, that I located and had lunch with Roger Sinott of **Sky and Telescope** (at this point you're not supposed to chuckle, because, believe it or not, we get along perfectly well). I also met Robert Petrey of **Star and Sky**, and we talked about things that magazine people talk about, like paper, postage, and printing.

After lunch, Ben Mayer delivered a talk that left me stunned. It was about the Stellafane

Ben Mayer fills his tank with "unleaded."

Top: Ashley McDermott opens the first paper session in the Camp Oakes meeting hall. This room has large windows at both ends; they were covered with black plastic and aluminized Mylar (Solar-skreen?) to keep it dark enough for slide presentations. Below: Snow-covered peaks at 11,000 feet elevation glisten from 8400 foot Onyx Pass.

meeting of 1978, at which he was keynote speaker. Ben is a passionate speaker, his uninhibited fervor entrancing his listeners, until unsuspecting, they are drawn into the dramatic depths of his vision of astronomy. Last year at Stellafane his talk received a standing ovation; this year he wrung from himself the tragedy of his son's death which had occurred that same night, almost the same time, as he stood speaking on Breezy Hill. Afterwards, standing out in the glaring sunshine, it seemed impossible to reconcile the cathartic power he evokes with the prosaic glass and metal constructions that take us there.

As it turned out, my winter-pallid Milwaukee complexion was not up to hours under the California mountain sunlight; I burned. Despite that, the time spent for the awards committee was time well-spent, because it meant that I looked at more telescopes than I might have otherwise (ah, but how I wanted to spend an hour at the pool!). As for the sunburn, next time I'll know enough to wear a broad-brimmed hat.

In the afternoon, the awards committee met to choose the meritorious telescopes, and the choices were really quite easy. A list of awards and why they were given appears on page 36. You'll notice that I've mentioned some instruments in this TM that did not receive awards and omitted a number that did. My criteria for inclusion in TM don't exclude Merit Award winners of previous years (as the Merit Awards do), and I am also omitting instruments that will be described in the Conference Proceedings. I've also asked a number of telescope makers to write about their own instruments, and those articles will appear in future issues of TM.

Sunday night turned out to have the clearest and darkest sky, but tiredness, sunburn, and a strong desire to sit down somewhere led me into a long conversation with Mike Selden while the summer Milky Way rose. I've never seen the Milky Way like that before: from 44°N it's down in the murk except on rare occasions. (I've been in Hawaii twice, both times in winter, so I've seen Eta Carinae better than M-8!). The lights of L.A. are only a small glow in the western sky at Camp Oakes, buffered as it is by the San Bernardino mountains, and the clear dry mountain air scatters very little light. On Sunday night L.A. was buried in smog according to the radio, and the smog apparently dims L.A.'s lights somewhat more. I got in one final bit of observation: Earl Watts showed me Stephan's Quintet through his 16" Dobsonian reflector. This was something of a climax for me. I'd always thought of these as objects for a 200" telescope, but there they were.

Monday was departure day; many participants left early so that they could cross the desert before the heat built up. I stuck around until about noon, then left with Cliff Holmes to see Onyx Pass (8400 feet).

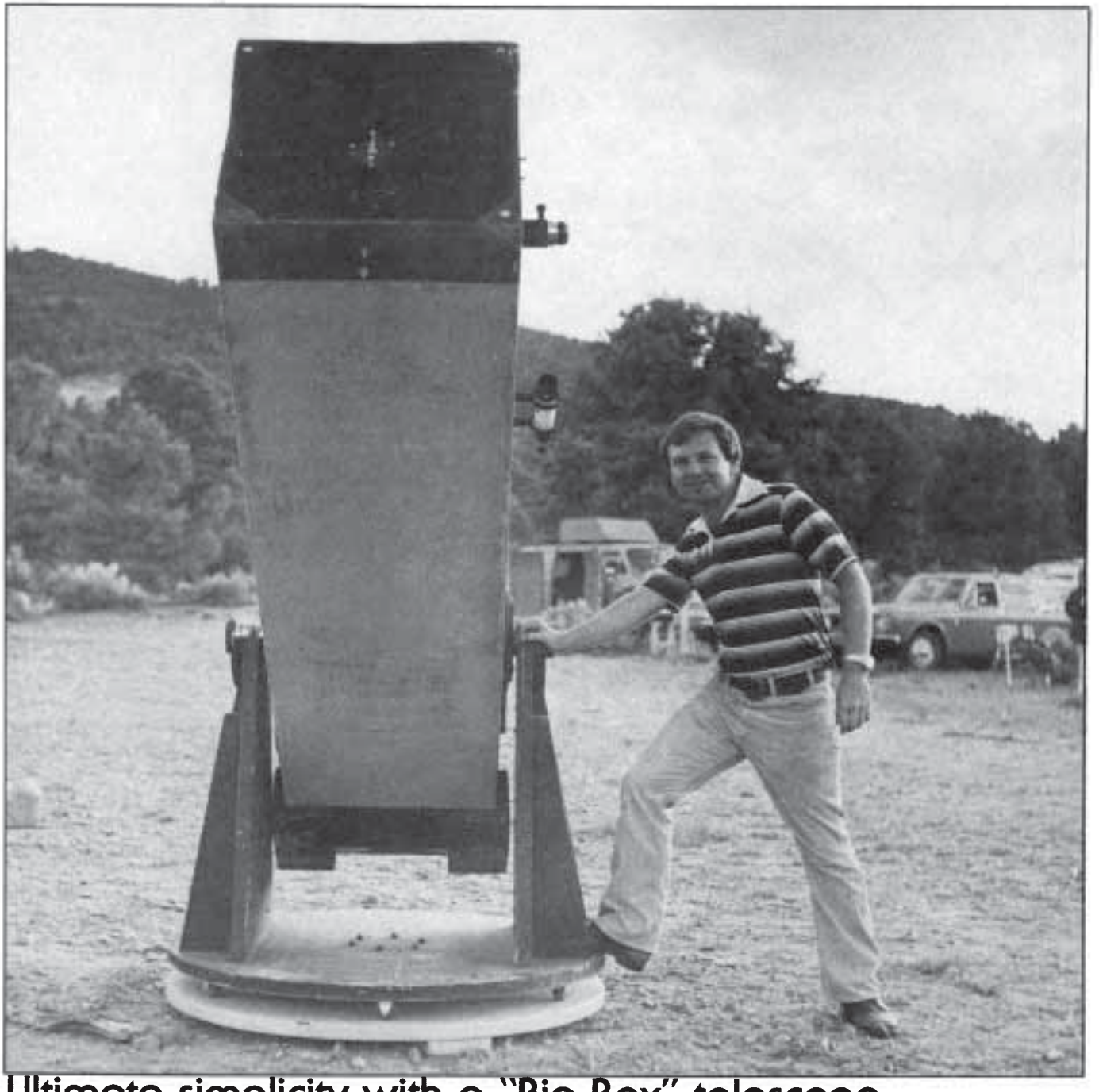
Cliff is the guy that started it all. His inescapable gusto (and yodeling) sparked the entire Conference; Riverside's 11th annual meeting is an achievement that he, and the others who organized and ran it, should feel proud of. The impact of these meetings on amateur telescope making is already strongly felt; the exchange and blending of ideas, emphasis on functional elegance, and refinement of techniques has given rise to designs that don't exist in the ATM books, and that Porter never thought of. I was sorry when this meeting broke up as I was carried away by it all, filled with a cosmically-oriented awe at the things I'd seen — almost to overdose levels — in the telescopes.

I hiked up to the summit south of the road, admired the scenery, took some pictures, hiked back down, ate lunch (crackers, jelly, and Coke again), drove down to Running Springs, checked into a motel, and got 12 hours of much-needed sleep.

On Tuesday, I toured Celestron's factory with Alan Hale and Thomas Johnson. I must say that Celestron's manufacturing operation, and especially their quality control, is very impressive. (This tour will eventually appear in some future issue of TM.) Leaving Celestron, I participated in a Los Angeles social ritual, namely rush hour, to accept an invitation from Myra and Cap Weir, spent part of the evening playing "Star Trek" on their microcomputer, and got to see the Pacific Ocean. Next morning I wrote the first few pages of this report on their typewriter, and that afternoon flew back to Milwaukee.

Richard Berry
Editor
Telescope Making

Mike Hatcher and his 22″ reflector.



Ultimate simplicity with a "Big Box" telescope

The 22″ f/4.5 Newtonian altazimuth-mounted reflector owned by Mike Hatcher of Riverside was the biggest telescope (i.e., having the largest aperture) at the Conference this year. Mike bought the instrument from Dick Nelson (Optical Craftsmen) who ground the full-thickness mirror and constructed the mounting.

The tube is ⅝″ plywood, square, with no internal bracing but triangular pieces roughly 3½″ wide in the corners. Short lengths of doubled-up ¾″ plywood approximately 7″ x 10″ attach the mirror cell to the tube. I didn't see the cell outside the tube, so I don't know how it is constructed. The azimuth trunnions are approximately 2½″ in diameter and turn in a plywood cutout. A bracket over the top of the shafts controls the drag in the bearing.

The arms of the fork are doubled-up ¾″ plywood plates with three heavy buttresses for stiffness, and the base is a doubled-up ¾″ plywood circle. The base has a surprising degree of stiffness; flexure in it could produce backlash because the fork arms would bend to follow when torque is applied to the tube, then relax when the pressure is released. This effect is absent, however. The fork base rotates on six hard-rubber casters that ride on a ground plate, again made of doubled-up ¾″ plywood. The composition of the wheels is important because a material too soft will have too much friction.

Performance of the instrument was very impressive, not only optically (see August ASTRONOMY Forum), but also mechanically. True, it's not a precision mount, but there are no insufferable problems in using it. Friction is somewhat high compared to what I'm used to in a telescope, but a good solid shove gets it moving in either axis with no difficulty; fine pointing adjustments from the eyepiece were easy and there is no backlash. It's fun using this telescope because you don't ever need to feel delicate about using it. From the finder, located low on the side of the tube, it's difficult to handle the tube because there's no way to grip it. A few handles would help.

This is certainly a viable method of mounting a large mirror, especially if you want to get started observing quickly. The stability of the image and ease of use exceeds that of many conventional equatorially-mounted telescopes. ■

unobstructed apertures...

Arthur Leonard stands beneath his 6" Yolo unobstructed reflector, displaying models of improved secondary mirrors.

The secondary obstruction in Newtonians, Cassegrains, and catadioptrics causes a loss in image contrast. Although unimportant in resolving double stars (which are exceedingly high-contrast test objects), the loss is noticeable on low-contrast planetary detail. Refractors, and more recently, unobstructed reflectors such as the Schiefspiegler and Yolo designs, offer the full measure of visual telescope performance.

Arthur Leonard, of Davis, California, brought a 6" f/18.8 Yolo that provided an extremely fine image of Saturn at about 500x. Pictured above, light enters the tube at upper right and travels down to the first concave mirror at lower left, returns to a second concave mirror (just above Mr. Leonard's head), then down to the eyepiece at left. To remove residual aberrations, the secondary is deformed slightly by a "flexing harness." Its job is to increase the radius of the mirror slightly in one plane, while reducing it in the other.

One of the problems with the Yolo, however, has been that the flexing harness required an oversized mirror. Now, smiling broadly, Art Leonard displays two wood models of his new secondary mirrors, shaped on the reverse surface so that a simple flexing harness can deform it. With these improvements, the Yolo design may now appeal to a wider range of telescope makers.

for superb resolution

Refractors are common enough in the smaller sizes today, but rare much above a 6" aperture. That didn't stop Jeff Schroeder, of Pomona, California, from constructing an 11" f/16.5 instrument that's become one of the landmarks of the Riverside meeting. With a focal length of 182", plus dewcap, plus ground clearance, the tip of the tube spends a lot of time more than 20 feet off the ground!

I didn't get to see Saturn, but was told I should have. M-13 was pretty spectacular though, and the star images were obviously quite good. The instrument's length and weight make it somewhat limber however, and after making a position change, it tends to "boing" back and forth for several seconds. Welded and machined from steel, the whole mount knocks down for transport on a trailer. The telescope tube itself travels both ends open in a cradle on top of Jeff's car.

This telescope was fully described in the March 1978 **Sky and Telescope**, page 257. It's an important instrument because this is what the public thinks of when it thinks of "telescope." It's huge, impressive even outdoors (where so many telescopes suddenly turn small), and best of all, you look in the bottom end! Even the most avid big reflector fan must admit to a bit of atavistic thrill — maybe something left over from the days of Hevelius — when confronted with a big refractor.

Myra Weir sights along the tube of Jeff Schroeder's 11" refractor; Jeff at the eyepiece end of its tube.

Doug Berger and his 16½" Dobsonian reflector, opening the rear hatch to see the mirror.

Several years ago a new, simple telescope design appeared on the West Coast. Used for popularizing astronomy by the San Francisco Sidewalk Astronomers, telescopes of this design provided thousands of people their first look through a telescope. It's the ideal design for any telescope maker who wants a bigger telescope than he thought he could ever afford.

What's it got going for it? First, it uses simple materials: plywood, plastic, cardboard. Machine tools are not necessary. Second, it relies on clever design, based on sound principles of physics and engineering, rather than mass and precision fit, for its performance. Third, by providing a fast, convenient, large aperture instrument, the design meets the needs of a growing number of deep-sky observers.

Doug Berger's 16½" "Das Edelweiss" is bright yellow, but scraped up enough that you know it's seen lots of use. In azimuth it turns formica and teflon pads; in altitude it runs on two discarded phonograph turntables bearing on two teflon pads each. The motion must be felt to be believed: no sticking, grabbing, or backlash.

Now for the big surprise: the mirror is made out of porthole plate glass 1⅛" thick! The images it gives are excellent; it won a Merit Award in 1976 for optical quality, but I'd

large portable aperture...

...and ease of use

already tabbed it as one of the better performers after using it Friday night. The mirror works well, even though it's thin, because it is supported radially by a simple strap, and from behind by a nine-point flotation system. Doug stops it down for use as a 6" unobstructed reflector on nights when the seeing is poor.

The telescope is taken apart for transport. The tube goes on top of the car; other parts go inside with the camping gear. Set up and knock-down go very quickly because the parts basically just drop together. Mirror access is provided from behind (see photo); the whole end of the tube is hinged and opens. The mirror, in its cell, is removed from the telescope, covered, and carried separately.

Earl Watts brought a handsome 16" dark blue telescope down from the San Francisco area. His instrument rides on a piece of formica turning on three teflon pads about 1 inch square (see photo). The centering pin is a $\frac{1}{2}$" bolt. A washer and wingnut on the bolt increase the friction in the azimuth bearing if he wants it. In altitude, the telescope turns on a section of large-diameter PVC pipe about an inch long held to the side of the box with wood screws. The tube, of painted "Sonotube," slides into the the large box against a layer of felt, so it's removable, but he usually transports the assembled tube structure in the back of a van. ■

Earl Watts displays the azimuth bearing of a Dobsonian reflector; the instrument is dark blue.

elegant design in tubing and framework

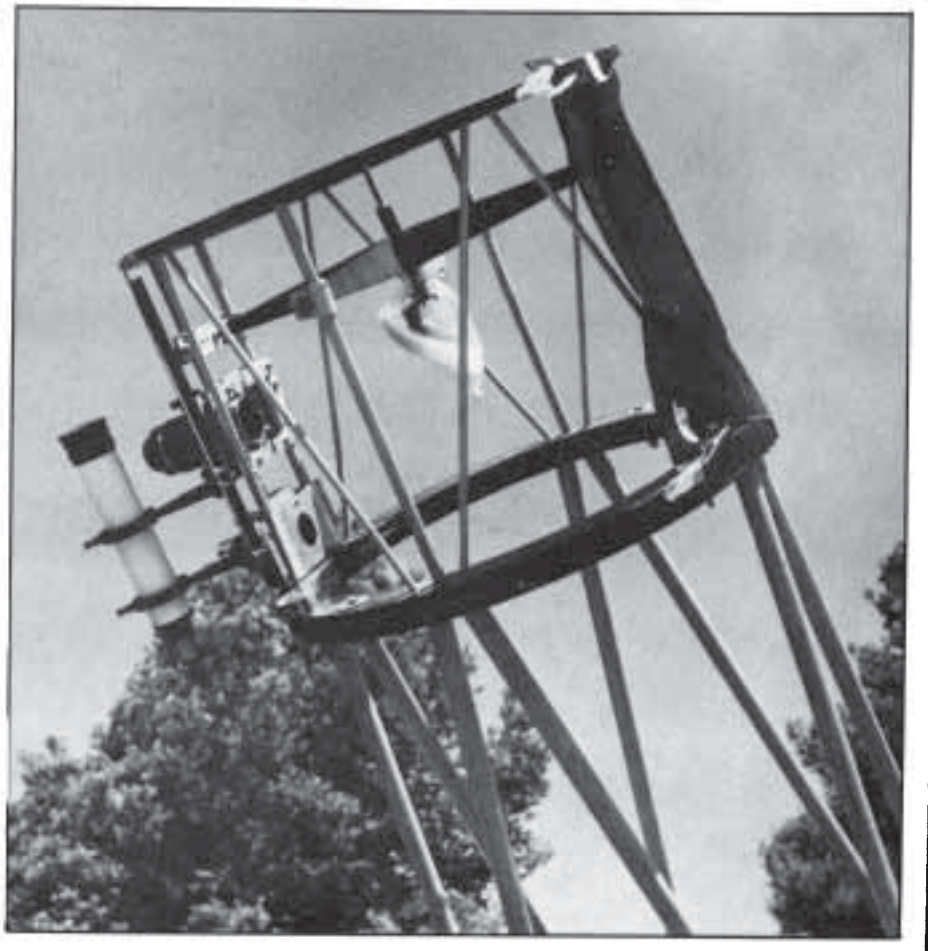
Framework tubes have been popular ever since the giant professional reflectors began using them at the turn of the century. A lot has been written about the advantages (no air currents in the tube) and disadvantages (heated air can enter the optical path), but in amateur-sized instruments the choice is really an aesthetic one. Open tubes look good, they're very light, and if you're building your tube, they're relatively easy to construct.

The classical tube design by Allan Ruckle, of La Mesa, California, is made of wire-welded EMT (electric metallic tubing) conduit, 1" diameter with 0.049" wall thickness. Curved parts (upper and lower ends, declination box, and fork) are formed on a large precision bending machine; this work could be farmed out if you can't get access to such a machine. The fork is made of heavy-duty rigid conduit, the base of welded steel angle, the drive is a $10\frac{1}{2}$" Byers drive. Mr. Ruckle commented that "everybody who comes by shakes it — what's the matter?" Well, it looked shaky, but it turned out to be very solid, belying its appearance.

The mirror cell is an interesting feature, probably the most nearly "naked" mirror I've ever seen. There is a close-fitting plastic cover for the mirror, and for transport three large wingnuts permit removing the mirror, its flotation cell, and cover.

Astrophotographers normally shun open tube designs because stray light can reach the film during exposures in some designs. Not so with Kevin Medlock's 18" f/4.6 quartz-mirror Newtonian. The Newtonian secondary is mounted on a tube suspended from the tube front end ring by four thin wires. This tube serves as more than a support for the Newtonian secondary, however. By removing the secondary from the bottom of the tube and placing a film holder at the top, Mr. Medlock converts it to a fully baffled photographic system, with the support tube serving as light shield. Guiding is done with a smaller telescope mounted on the declination box of the main tube. The telescope is constructed of aluminum throughout and

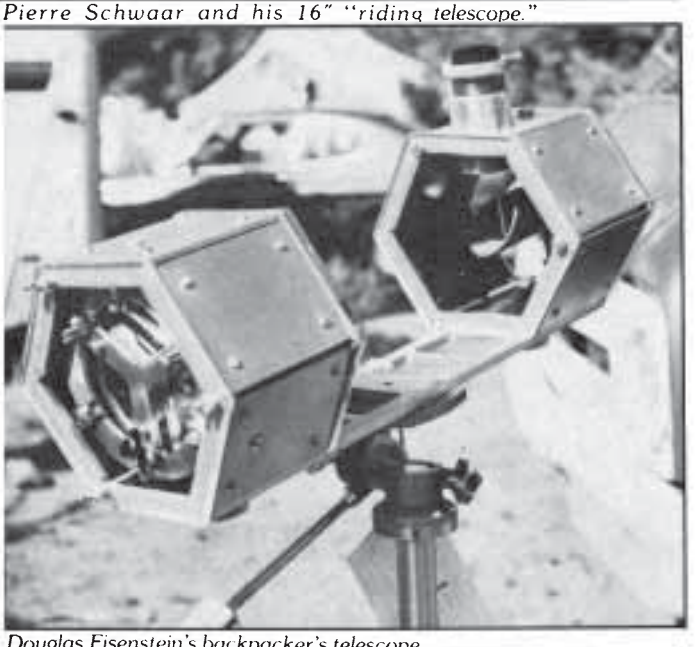
Left: Allan Ruckle's 14¼" open tube reflector is elegant, light, and vibration-free. Note the large 11 x 80 finder telescope. Below: The mirror in Ruckle's telescope is open to the air. Above: The secondary in Kevin Medlock's 18" reflector is supported by thin wires; right: with the flat removed, light travels up the central baffle tube to the camera unit. Note the large focusing ring. Below, right: The framework of Bill Hall's 16" reflector is made of broom handles and dowel rods. Lighter still than metallic tubing, wood provides reasonable tube stiffness.



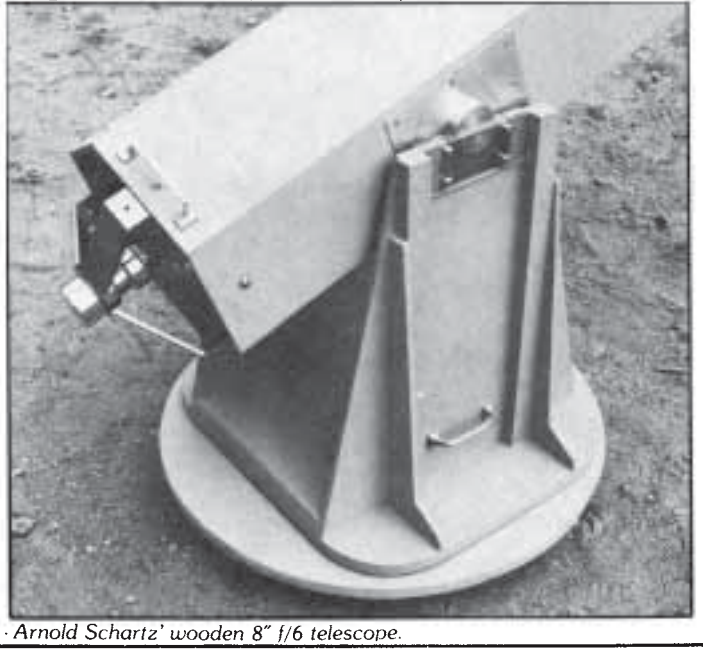
weighs about 350 pounds.

Bill Hall, of Downey, California, has shown that framework telescopes need not be welded metal structures with his 16" Newtonian. The mirror and its cell ride in a large plywood box, but the tube itself is open, and made of eight wood broom handles. This structure is extremely lightweight. The "upper-end," two plywood rings joined by 3/8" and 5/16" dowel rods looks undersize, but is quite rigid. The main eyepiece holder and a second photographic guide eyepiece holder are attached to this structure. Its ring detaches from the ring at the top of the tube for transport. Mr. Hall uses opaque plastic to block stray light from the eyepiece.

Pierre Schwaar and his 16" "riding telescope."



Douglas Eisenstein's backpacker's telescope.



Arnold Schartz' wooden 8" f/6 telescope.

1979 Merit Awards

Most Daring Mechanical Engineering
Pierre Schwaar

A 16" telescope that carries the observer along with it in a chair; uses alt-azimuth mount and surplus motors, battery powered; will carry an observer up to 150 pounds. Used to give "Tours of the Universe" to the public.

Best Wooden Mount
Arnold Schwartz

An 8" f/6 alt-az telescope in a hexagonal tube; rides in aluminum/lexan bearings in alt, waxed formica on formica in az; good workmanship throughout, parts routed and groved together.

Improved -BLICOM
Ben Mayer

VIBLICOM — VIdeo BLInk COMparator enlarges the capabilities and speed of PROBLICOM survey work by displaying alternate pictures on a television screen; can scan negatives as well as positives, less eyestrain, faster.

System Concept and Unique Electronics
San Jose Astronomical Association

A CID camera system; a group project involving many talents; 128 x 128 pixel camera head obtained for $1000; support electronics and documentation done by the SJAA.

Excellent Design for a Solar Telescope
Mack Wagner

A 10" solar telescope uses a heliostat mirror and simple lens to form large solar image for use with prominence filter; eyepiece and filter supported on camera tripod at focus.

Design Concept and Craftsmanship
Steve Kufeld

A counterweighted mounting for large binoculars; allows users of different height to move binoculars without losing the object from the field.

Mechanical Stability and Construction
Duane Niehaus

A 5" f/4 telescope on an exceptionally steady mounting; three heavy tripod legs and a central column provide a solid base for a well-made mounting.

Best Observing Accessory
Blayne Lequex

An illuminated chart table; variable brightness; filing system for finding charts and tables.

Backpackers Telescope
Douglas Eisenstein

Unique Drive Concept
Allan Guthmiller

Outstanding Craftsmanship
Malcolm Browne

The Warren Estes Award
"for the best use of simple materials"
Bruce Smith

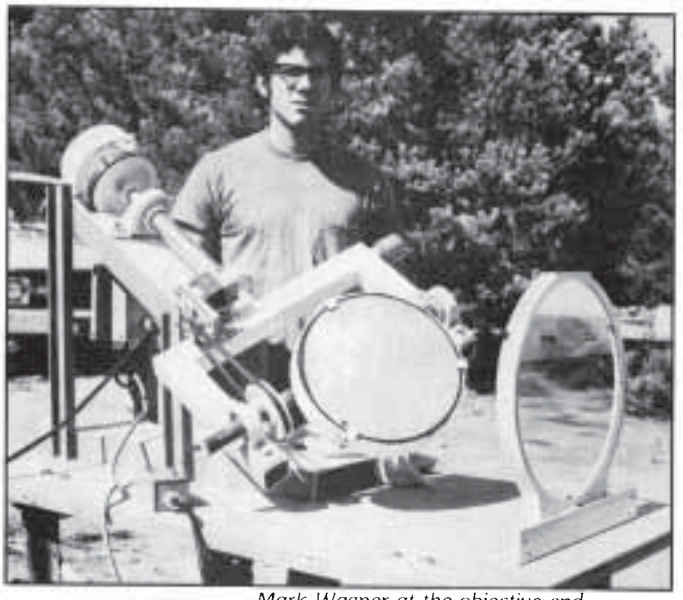
A sand-driven telescope; sand draining from a container lowers a weight which drives the telescope in R.A.

Junior Merit Award
Vance Chin

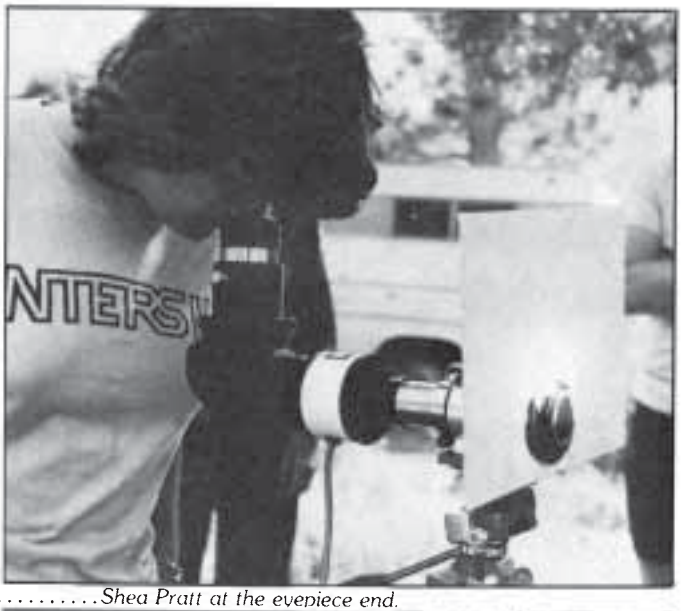
A 6" RFT; uses an impressive range of scavenged and salvaged materials for his telescope, including a five-legged office chair base.

Riverside Telescope Maker's Conference Award
Arthur Leonard

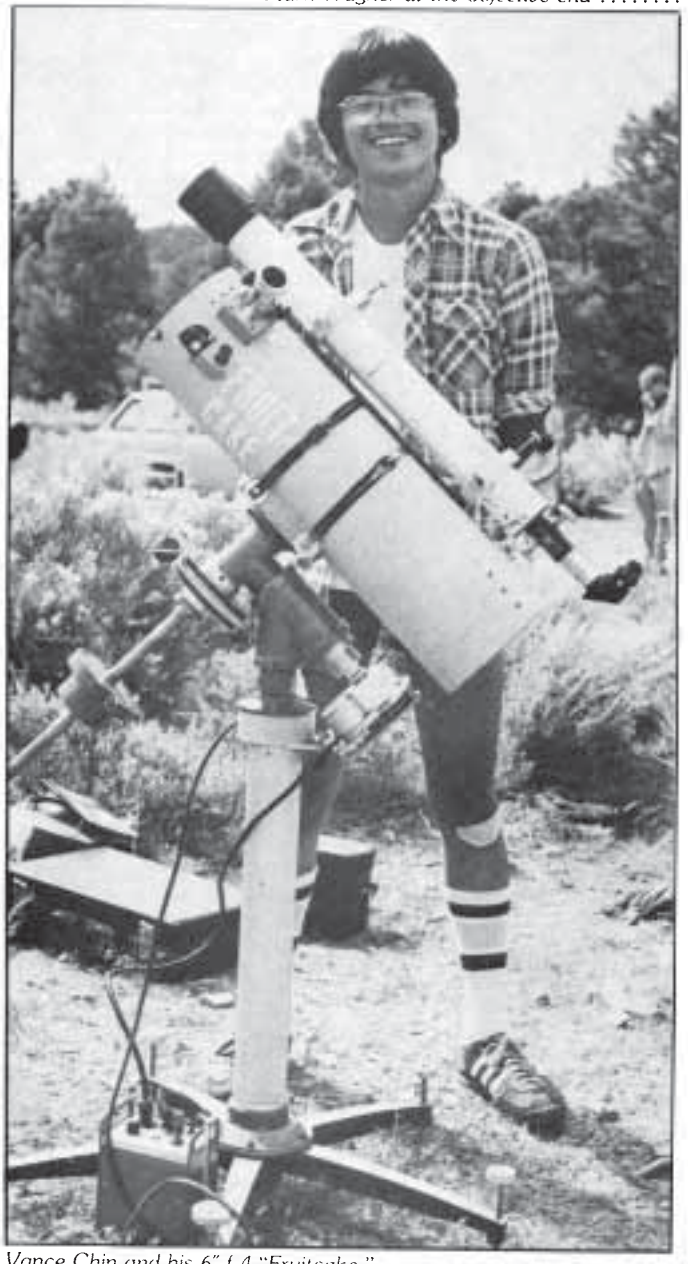
"the person who has done the most for amateur telescope making"
$50 cash award



Mark Wagner at the objective end .....

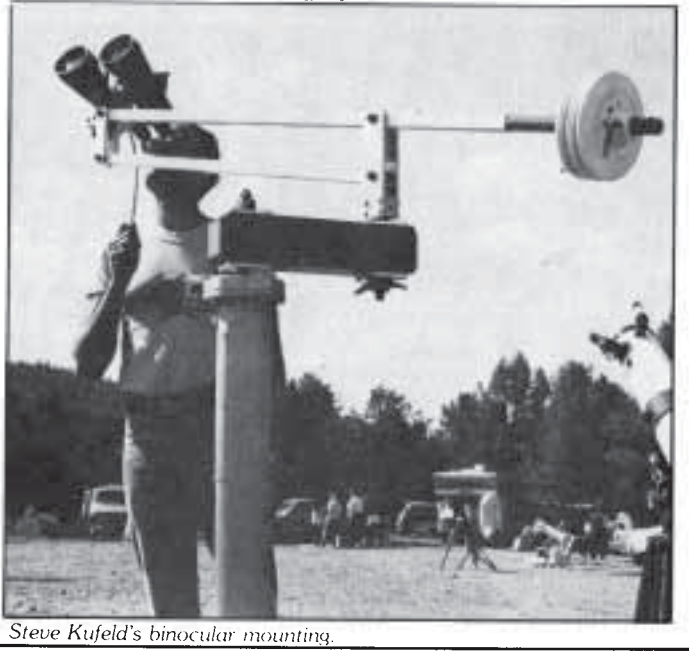


.....Shea Pratt at the eyepiece end.



Vance Chin and his 6" f 4 "Fruitcake."

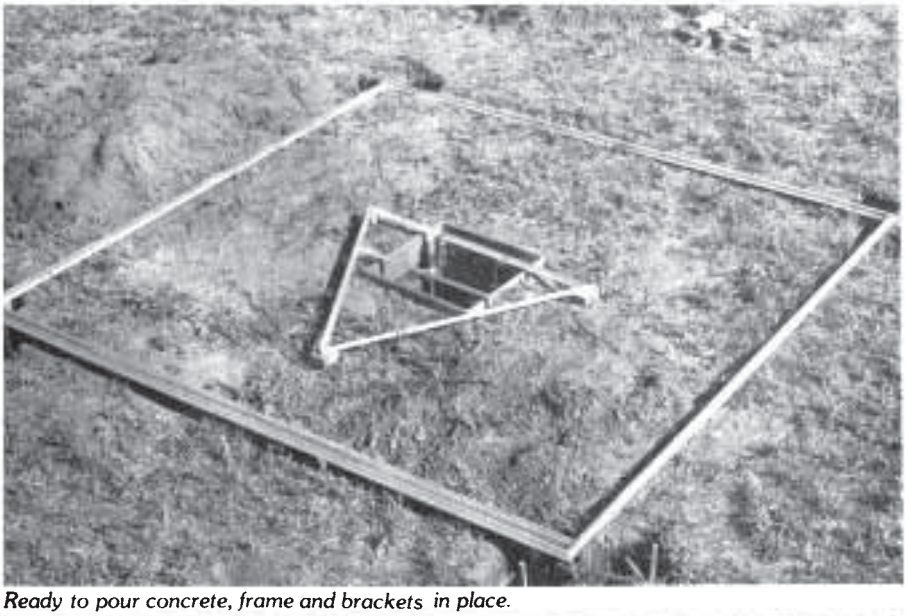
Very stable tripod mounting by Duane Niehaus.



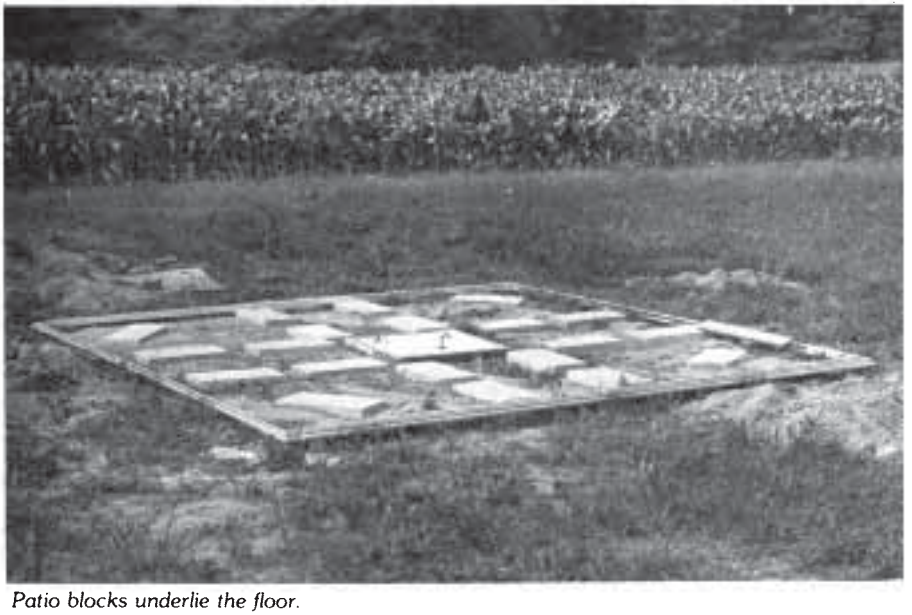
Steve Kufeld's binocular mounting.

A Ready-Made Building for a Backyard Observatory

by
Howard F. Zeh



Ready to pour concrete, frame and brackets in place.



Patio blocks underlie the floor.

To house my first permanent telescope, I chose a Ward's backyard building. This was later to house my 8″ Newtonian and three other subsequent telescopes. The building I chose was the approximately 10′ x 10½′ one.

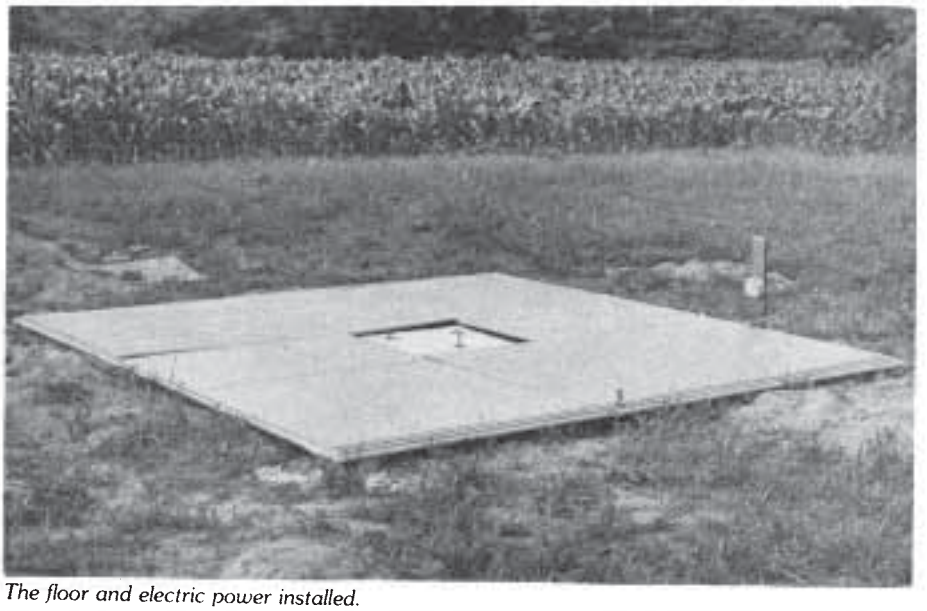
The concrete base which was to support my telescope's cast-iron pier was formed by simply digging out a hole about 42″ deep, 28″ to 30″ wide at the bottom and about 20″ square at the top which is just above ground level by about 1½″.

The cast-iron pier was intended to be bolted down with three bolts. To anchor the bolts into the concrete, I attached each of the three bolts to a 1″ long section of rectangular steel tube measuring 3″ x 6″. I drilled a hole in one of the 3″ sides of each tube and tapped it for a ⅜″ bolt. These were held by a triangular jig approximately 120° apart so that the bolts would just clear the base thickness of my cast-iron pier. The jig was leveled and supported while the hole was filled with concrete, so that the 1″ x 3″ bolt hole ends were ½″ above the concrete top level — which was at ground level. After the concrete had set, the jig was removed.

Next the anchor frame which came with the building was placed, assembled, and leveled, after which the four corners were set in concrete posts. They are approximately 8″ in diameter and I made them just as described in the instructions which came with the building.

Before assembling the building, I made the observatory floor which started out from 8 sheets of ½″ plywood (4′ x 8′). These were cut to to fit inside the building frame at the bottom of the walls, and allow about a 20″ x 20″ opening in the center to clear the concrete base. We laid the pieces down in "swastika" fashion, two lapped ½″ plywood sheets forming a 1″ thick floor with the seams staggered. After painting these with a good grade of porch and deck enamel — two coats — I assembled them on 18 standard patio blocks carefully leveled on the sandy soil. The blocks support and hold the floor level while allowing air circulation underneath. The painted sheets of plywood were fastened together with many plated wood screws to form a "one-piece" floor.

Working alone, I assembled the building corners and sides using temporary guys to



The floor and electric power installed.

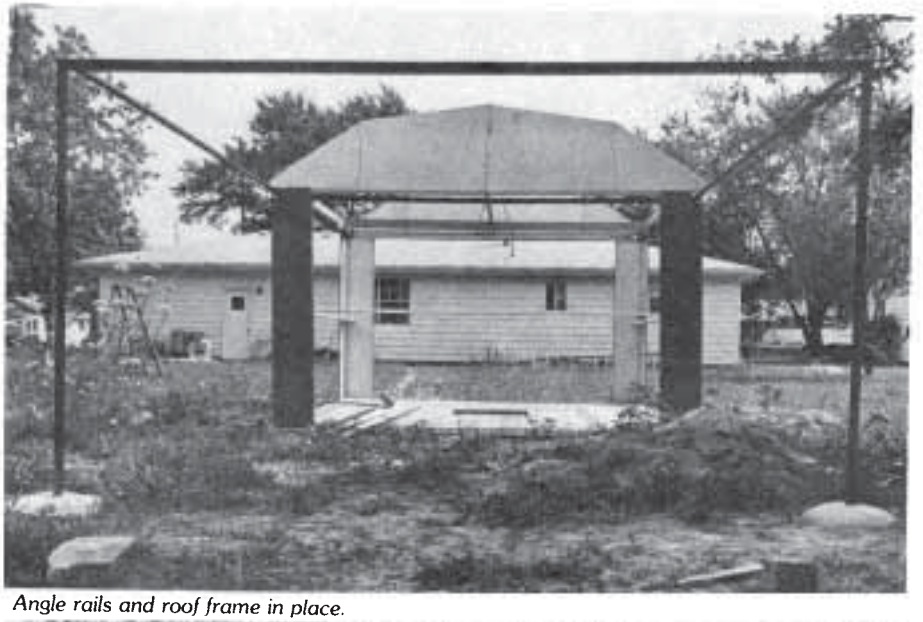
hold things until I could put in all the supplied fastenings. Normally these buildings depend on the roof to support the upper end of the walls and vice versa. In my observatory, the supports for the top edges of the walls are pieces of 1½" steel angle. Two 20' pieces act as rails on which the roof wheels roll. Ten feet of each rail extend beyond the rear of the building and were held in place with simple "scissors" of 2 x 4s until they could be fastened to the upper edge of the walls. I used 10-32 plated machine screws at about 10" intervals in pairs, one on each side of the strengthening bends in the walls.

The outside rear end of the rails was simply bolted to similar steel angle uprights set in concrete. Further bracing with steel angles across the building rear as well as the rear end of the rails outside completes the structure. Similarly, a smaller 1" x 1" steel angle served above the sliding doors at the building front. Since the building material is thin steel, I used many fastening screws.

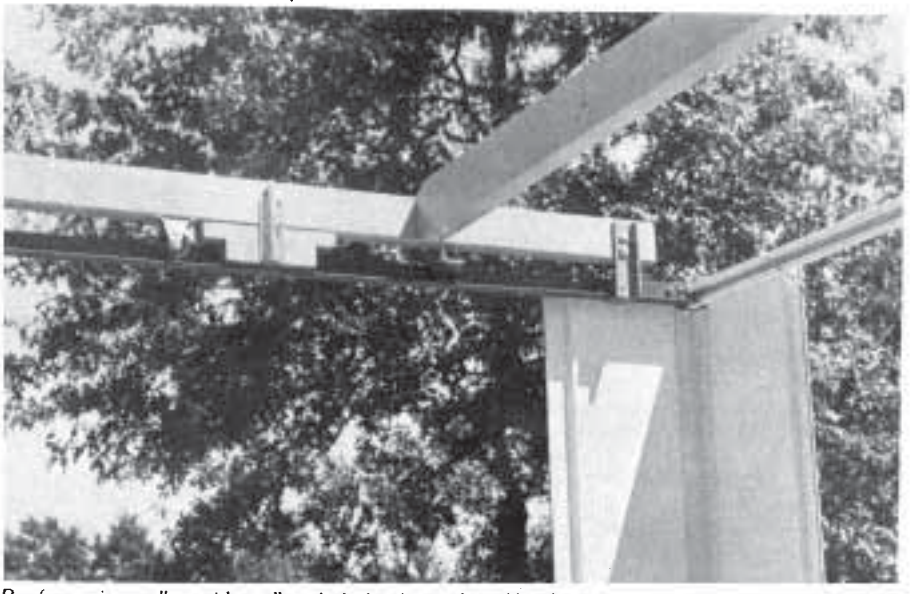
Next the roof frame was made from 2 x 4s and suitably angled to mate to the roof slope, as well as provide the proper clearance between the roof and the main building. It can't be so low that it drags, nor so high as to permit wind-blown snow and rain to enter. I mounted a series of 2" diameter rubber-tired wheels (similar to casters but without swivels) to the underside of the outer sides of the roof frame, three on each side to support the weight of the roof, plus two on each side at right angles to keep the roof support wheels from leaving the track, and then raised the frame to the tracks. The roof was assembled to the frame and plenty of plated wood screws used. Of course, I painted the wood frame and the steel angles before assembly with a rust-resistant protective paint.

Two standard ⅛" door bolts are mounted to the roof frame along the sides near the front of the building and sloped so that suitably drilled ⅛" holes provide a firm latch to keep the wind from opening the roof when it's closed. The holes were drilled to work slightly against each other so that the roof can't move back and forth with the wind. Hooks secure the roof against lifting off.

This observatory building has been in ➤



Angle rails and roof frame in place.



Roof-carrying roller, side roller, bolt latch, and roof-hook.

Complete observatory with 8"' reflector; Saturn, taken from the observatory with the 8-inch, 14 seconds at f·135 on SO·410 film, February 16, 1977.

Ready-Made Building

constant use for 5 years and has lived up to my hopes in every respect. At this latitude and farther north some care must be taken not to allow too much snow accumulation as it might bend or collapse the roof. I usually clean the snow off frequently, using a step ladder and push broom. Three inches of wet snow is quite heavy! But while it may be safe from collapse, the roof will not, in my case, open easily if there's too much snow because the rubber-tired wheels compress under the load. Without snow, the roof pushes back by hand rather easily.

During the beginning of work one chore was to dig a narrow trench between the rear wall of the house, 66′ to the observatory, to allow the use of buried 115 VAC electric line.

Since for appearance's sake I had the observatory front facing south (toward the rear wall of our house), I arranged it so that the roof rolls back toward the north. This usually blocks Polaris; however, with a few minutes work, I can remove the roof hooks and roll the roof about 3′ beyond its normal limits.

The mounting and cast-iron pier have supported my 8″ planetary Newtonian and my twin deep-sky telescopes on the same mounting (one a 6″ f/7 Newtonian, the other a 6″ f/4 working at f/5). Lately I poured a new concrete pier on top of the original. It is about 17″ to 18″ at its base and about 10″ to 12″ at its top. Atop it rests a ½″ surface ground steel plate which is bolted to internal pier anchors. On this, the standard C-14 "wedge" is fastened, providing a very stable platform for my C-14. In every way the concrete pier is superior to a former one, which was made of steel tube 10″ O.D. with ¼″ wall and ½″ steel plates on bottom and top. This steel version should have been sturdy and stable but seemed to suffer from a resonance to the tiny 5 watt synchronous R.A. motor of the C-14. The concrete pier totally eliminated this. I can lean on the concrete pier without any excess vibration. A sharp kick is rapidly damped out.

There is a single track railroad about 500′ away which causes some vibration, but surprisingly little. In any case I simply close the shutter while guiding a deep-sky photo, until the train has passed.

Howard F. Zeh
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Temperance, MI 48182

■

pier heads for backyard observatories

by Earle F. Dodds

In my article on "Permanent Piers for Backyard Observatories" in TM 2, I made a couple of fleeting references to "pier head" design. If you make your pier out of pipe or tubing, you'll need some kind of fitting to attach the telescope mounting to the top of the pier. This part is the pier head, and this article will address itself to how this component can be designed and built.

The pier head must not only accomplish connecting the mounting to the pier, but it must also provide means for orienting the mounting so the polar axis is parallel to Earth's axis. In fact, the precise alignment of the polar axis is almost entirely up to the pier head, although the general design of the instrument should result in this axis being approximately in the proper position. Without being too dogmatic about it, you might well say that the first thing that an amateur astronomer who intends to set up a backyard observatory should do is determine exactly where he wants the pier to be; second, he should determine within a degree or two the direction of the meridian through the pier; and third, he should determine, as accurately as he can, the latitude and longitude of his pier.

To achieve precise alignment, the polar axis must be rotatable in azimuth about a vertical axis — usually that of the pier — and tiltable in latitude around some kind of horizontal axis.

Most commercially-manufactured (as well as many "homemade" Newtonian) reflectors have German-style equatorial mountings, use tubing or pipe for the pier, and most of them employ somewhat the same kind of pier head to attach the mounting to the top of the pier. In most cases, this part is a casting, although it may be a weldment. The lower section is either a stem or a cap, machined to fit snugly either into or onto the top of the pier, and it is secured in place with one or more setscrews. The upper part consists of a pair of fins or lugs, the inside faces of which are machined parallel and pierced by a horizontal bolt hole. A lug on the polar axis housing is machined to fit closely between the lugs on the pier head, and it too has a horizontal bolt hole through it. This lug fits between the matching lugs on the pier head and is held in place with a horizontal bolt which is a close fit for the bolt holes. The stem — or cap — end pivots vertically, in azimuth, within the top of the pier, and the polar axis tilts, in latitude, about the bolt, which is actually a hinge pin. The arrangement is simplicity itself; it is strong and rigid, and it is economical. It is also compatible with any latitude. The manufacturer doesn't have to tailor each mounting to fit a particular part of the country; any instrument, as it comes off the assembly line, can be shipped to Maine as well as to Florida.

However, before we decide that this design meets all of everybody's needs, it might be well to look ahead briefly to the procedure of precisely adjusting an equatorial mounting. The complete procedure is too lengthy and involved to be given in full in an article like this, so I will severely condense it. One of the early steps is to bring the 90° to 90° diameter of the declination circle into perpendicularity with the polar axis. When this step has been accomplished, generally it will be found that the circle will not read the correct declination of a test star which is centered in the eyepiece. The reading will differ from the correct value by the amount that the polar axis is tilted above or below the true latitude of the pier.

To remedy this situation, the telescope tube is turned in declination until the declination circle does read the correct value. The star will, of course, depart from the center of the field of view (fov). Your problem then is to loosen up the nut which clamps the polar axis in declination and tilt the polar axis, by hand — all the while keeping your eye glued to the star in the eyepiece — until the star is centered in the fov when the declination circle does read the correct declination of the star, and then re-tighten the nut.

If you have some kind of slow motion arrangement which will take over when you loosen up the latitude control hinge, this is fairly easy and direct, but lacking such a slow-motion mechanism, the procedure becomes exasperatingly difficult. A subsequent step — the alignment of the polar axis with the meridian — will involve rotating the entire mounting, along with the pier head, in azimuth to try to keep a test star from drifting off the center of the fov. Again, without some kind of slow-motion-in-azimuth mechanism, this step becomes most difficult.

The two photographs depict the top of the pier and the pier head of my own telescope and incidentally show the slow motion mechanism, in both azimuth and in latitude. The pier is a piece of plain-ended 4" pipe. The pier head consists of a base plate of ¼" steel plate, slightly larger than the equatorial wedge which rests upon it, welded to a standard 3" pipe coupling. This coupling, which acts as a stem, is held in place in the top end of the pier by a series of setscrews through the wall of the pier.

The equatorial wedge is a grey-iron casting, which is fastened to the base plate with a ¾" bolt. Tack-welded to the south side of the base plate is a short piece of ½" round rod which acts as the pin of a horizontal hinge. (It isn't necessary that the hinge pin be enclosed.) To the NE and NW corners of the base plate are welded lugs, and these lugs are drilled and tapped to take a ¼"-28 Allen-head setscrew. These act as slow motion screws in azimuth.

In the corresponding corners of the bottom plate of the wedge are two more slow-motion screws which control motion in latitude. Between these two sets of screws the wedge can be rotated in azimuth about the hold down bolt and tilted in latitude about the round rod at the south edge of the base plate. This arrangement allows precisely-controlled slow motions in both directions to bring the polar axis into accurate parallelism with Earth's axis. A somewhat academic point might be made as to whether or not the wedge is part of the pier head or part of the polar axis assembly, but that, as Scheherazade said to the Sultan, is another story.

These two photographs are offered only to illustrate the use of two sets of adjusting screws — there is no expectation that anyone might want to use a cast-iron wedge to support the polar axis as I did. One of the fascinating things about this hobby of ours is that we seldom work from formal plans and drawings — unless we make the plans ourselves — and the completed instruments are likely to be examples of self-expression. Accordingly, this article will try to deal with general principles and suggestions rather than in specific details and dimensions. We will

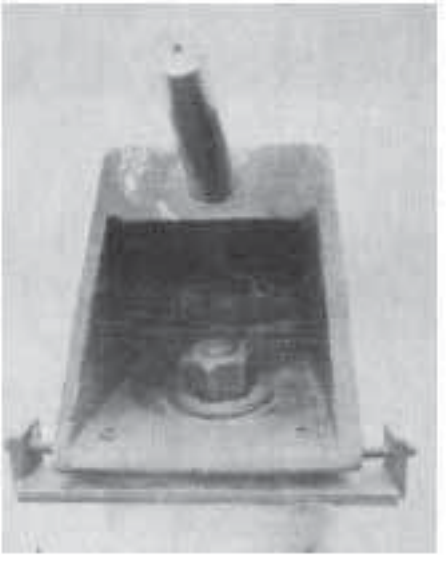

Figure 1

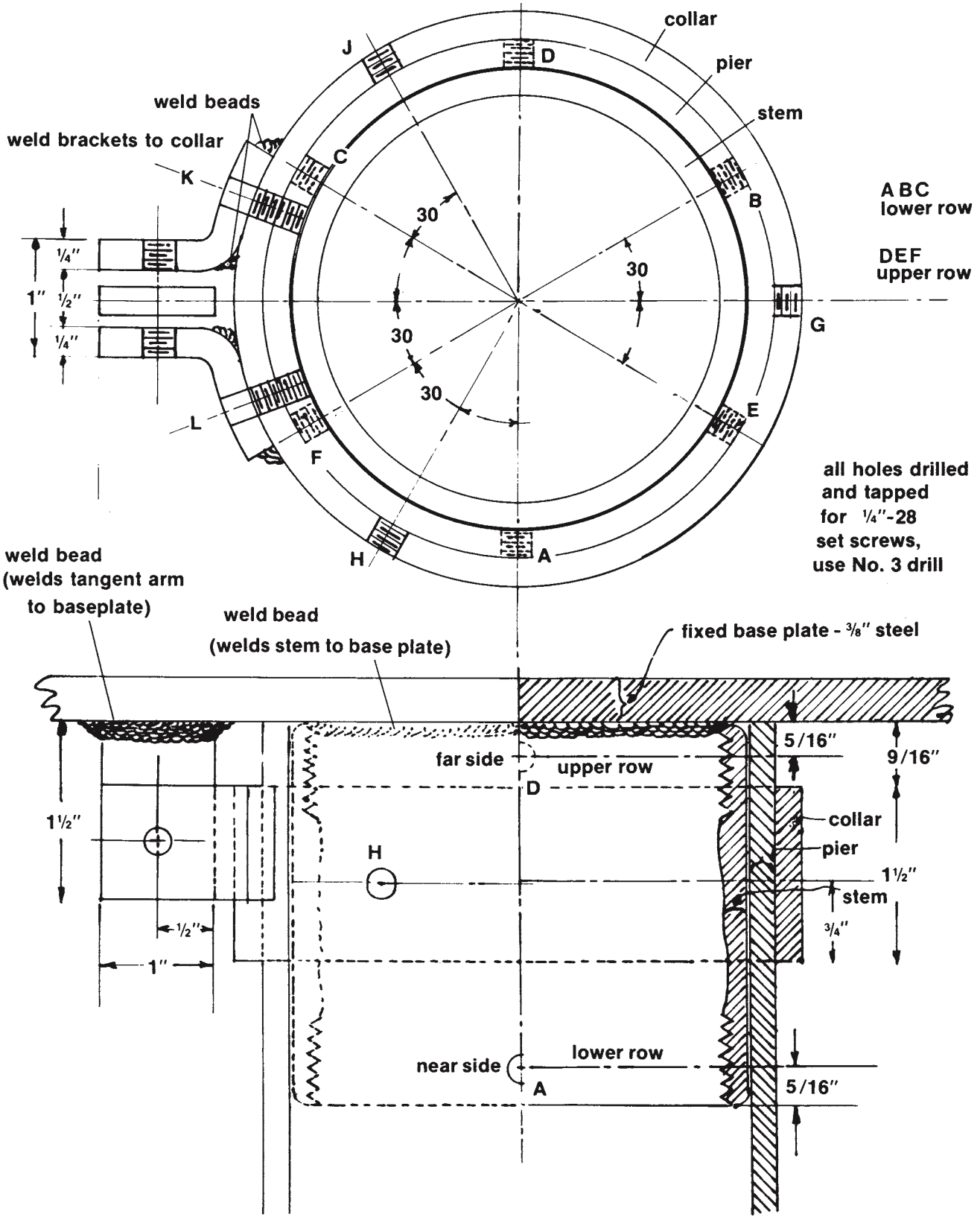

Figure 2

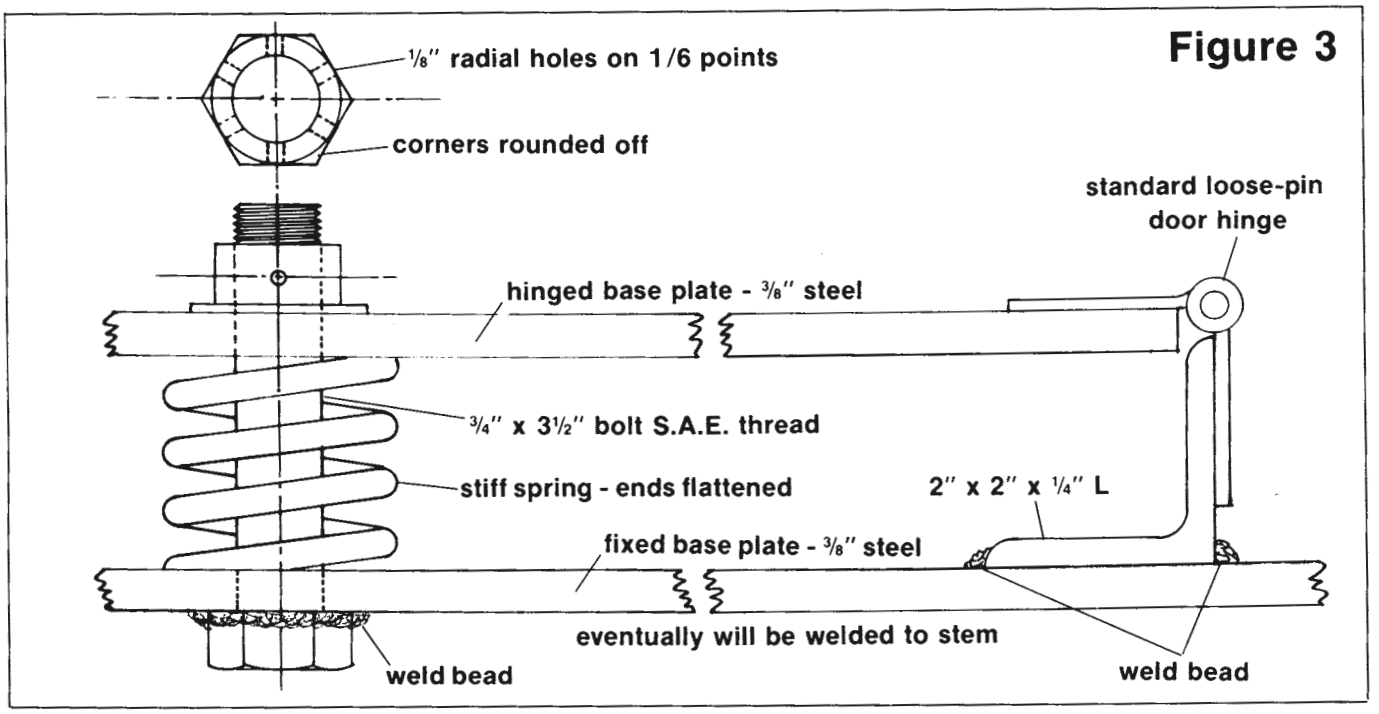

Figure 3

pier heads

indicate one arrangement which will allow you wide variations in designing the polar axis assembly and at the same time give you adjustability in latitude and azimuth.

The use of a standard 3" pipe sleeve coupling, acting as a stem and turning in azimuth inside of a 4" pipe pier, has worked out very well, and it is recommended. This coupling must be welded to the bottom side of the base plate, and the weld bead must be on the inside of the coupling, not on the outside. There will be a nominal clearance of 0.013" all around. The stem should be held in place with two rows of setscrews through the wall of the pier, but these screws should not be set up tight until after the final adjustment in azimuth has taken place. You may, when and if you are satisfied that the adjustment is practically perfect and you want to make it permanent, remove these screws one at a time and drill and tap the holes clear through the stem.

The stem and base plate turn as a unit about the axis of the pier under the action of a pair of opposing screws, operating through brackets fastened to the pier itself. These screws bear against a piece of ¼" steel bar stock welded to the bottom side of the base plate on the south side of the pier. This arrangement is, in effect, a modification of the tangent arm principle.

Rather than fasten the brackets directly to the outside wall of the pier, it would be much more convenient to fasten them to a collar which encircles and is later affixed to the pier. This arrangement will give you a little leeway in case you're not certain about the direction of the meridian through the pier. The arrangement indicated provides about 2° of adjustment on each side of the meridian, and this should be plenty. You can make this collar out of a 4" pipe coupling, cut off to about 1½" wide and bored out to be a slip-fit over the outside wall of the pier. Obviously it would be much easier to fit and fasten the brackets to this collar than to try to fasten them directly to the pier. Just as with the stem, after precise adjustment is accomplished to your satisfaction, this collar can be permanently bolted to the pier if you so wish. All you have to do is remove the setscrews one at a time, drill and tap the holes on through the pier — and through the stem, if you want to go all the way — and then use longer screws.

You will note that the dimensions of the base plate are not indicated in drawings 1 and 2, neither is the location of the stem with respect to the ends of the plate. It is impossible to determine these details until you have settled upon the design of your polar axis assembly. Russell W. Porter and Sam Brown, both yesteryear experts in telescope making, emphasized the desirability and advantages of having the center of gravity of the mounting vertically above the pier. It is not always possible to achieve this — for example, see the diagrams of pipe fitting mountings on page 56 of the January 1979 issue of ASTRONOMY — but it is worthwhile going that way as far as you can. But, until you finish the design of your polar axis you have no way of even guessing where the center of gravity of the tube-mounting combination will be. So don't be in too much of a hurry to weld that stem somewhere onto the base plate. Content yourself for the moment with making up the collar and the brackets, fastening them together, and doing what drilling and tapping that you can.

Drawing 3 suggests a method of accomplishing slow motion in latitude. This drawing is almost entirely diagramatic as compared with drawings 1 and 2. This is because the design of your polar axis will also have a profound effect upon the spacing and location of the hinge and the spring-bolt elements with respect not only to each other but also to the stem, which we couldn't locate even on drawing 2.

For slow motion in latitude, drawing 3 suggests a bolt and opposing stiff spring, rather than paired opposing screws. You need only one hand to turn the adjusting nut, and the availability of one free hand will be a big advantage during the fine adjustment procedure.

Up to now we have not even alluded to the width of the base plates. You might very well wind up needing a trapezoidal base plate, wider at the north end than at the southern, something like the situation I ran into with my mounting. You may need to use two hinges placed end to end to get the width you need, or you might want to use what is called a "T" hinge.

Other than paying attention to the indications "stiff" and "ends flattened," you have wide latitude for the spring. You may have to try industrial supply houses, hardware stores, or even junk yards to come up with a piece of spring that will be suitable. Bear in mind that you can flatten the ends yourself on a grinder. You will undoubtedly have to do this to obtain the correct length. You are not likely to get into trouble by having too stiff a spring, but you sure will if you get one that is too mushy. It should be stiff enough that it will not compress significantly under the load of the mounting and telescope tube. Let the bolt and nut do the compressing.

Somewhere, between the hinge and the bolt, you will utimately have to install the equivalent of an equatorial wedge to support the polar axis so it is substantially parallel to Earth's axis. You could even go to a set of matching lugs such as an ordinary pier head uses. You have many, many options available concerning the way you will build the polar axis assembly, but all of them ought to result in an alignment which is substantially correct for your particular latitude. All the springs and screws indicated in this article do is let you refine the approximate alignment down to a frog's hair. This may not be important if all you plan to do is "Oh, gee whiz" astronomy, but if you plan to have and use setting circles, it is absolutely imperative.

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A Homemade Declination Drive System

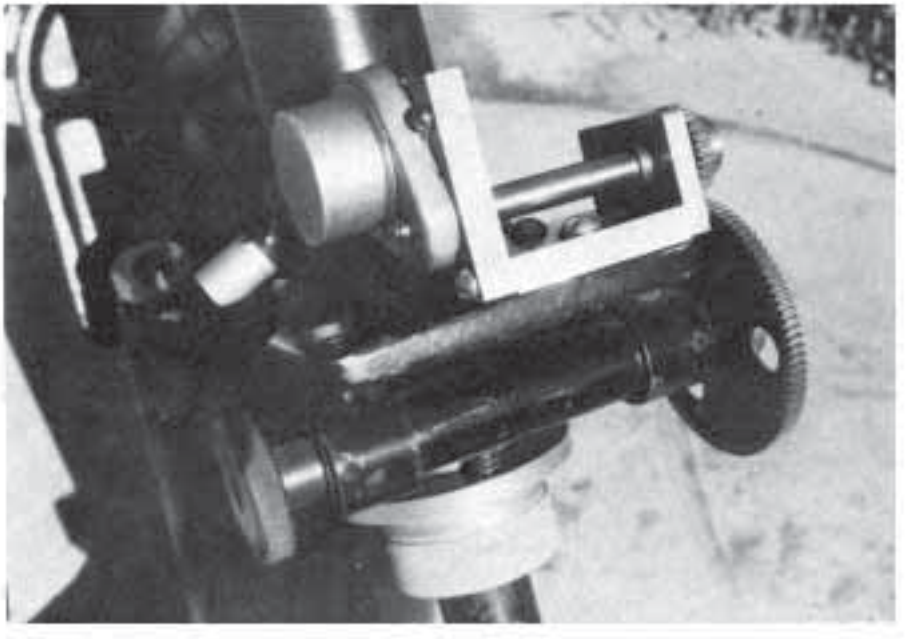
by
Robert L. Sandy

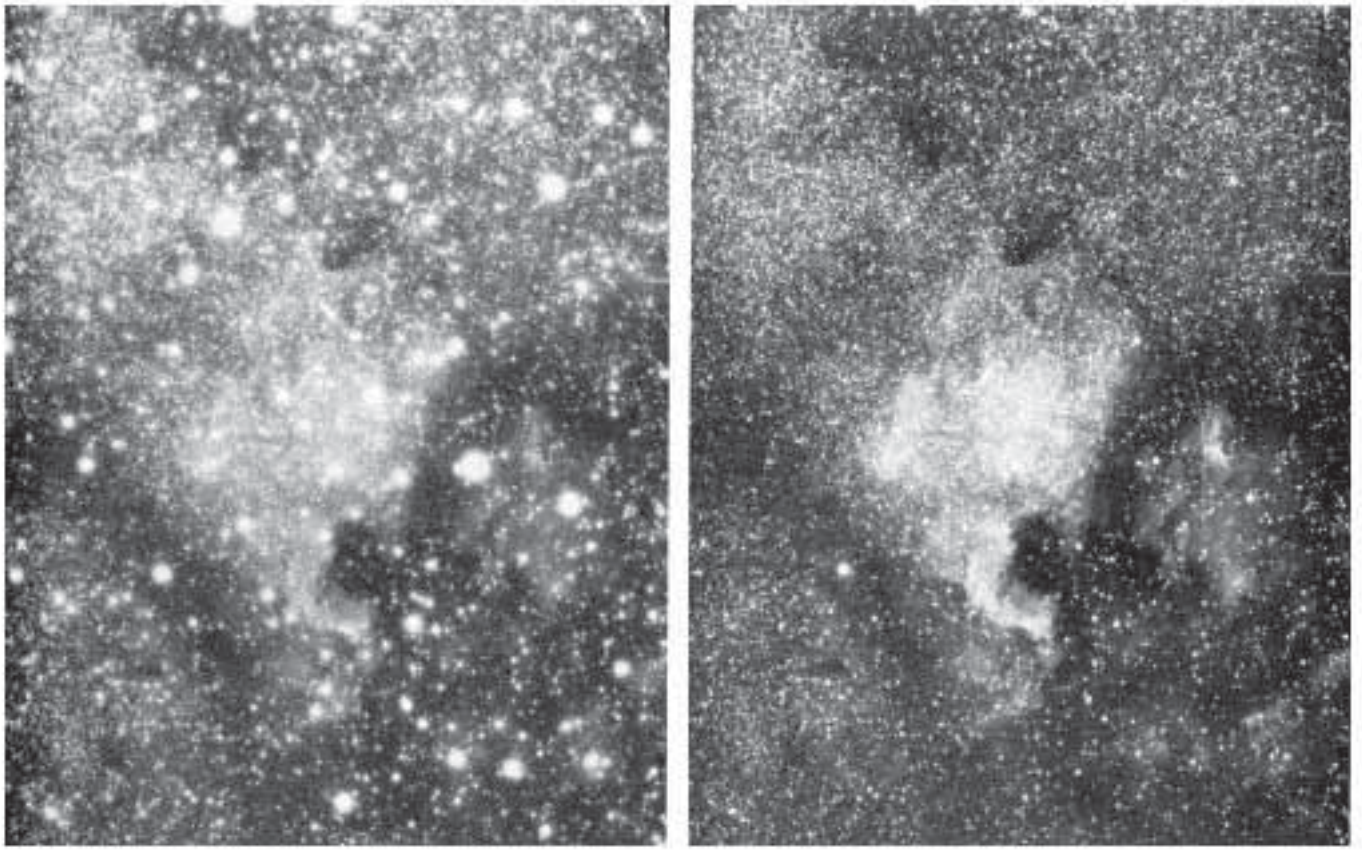
For seventeen years, whenever I made a guiding correction in declination, it was done manually. For astrophotography, especially during exposures up to an hour long, turning a knurled knob on the end of a worm shaft ever so slightly (and sometimes not so slightly) in the pitch black of night is not the best method. It worked well enough when using short focal length lenses on the cameras, where small errors don't show. But as I watched the guide star against the crosshairs, I noticed that a torque was applied in right ascension when I made corrections in declination manually. There were times when, in order to keep my eye looking through the tracking eyepiece, I had to reach out in the dark at full arm's length to make a correction in declination. It was always awkward and often there was the danger that a bump on the camera would ruin a valuable photograph.

Although my declination gearing (325:1) was fairly fine, one complete turn of the worm knob moved the telescope and camera 66 minutes of arc, coarse enough that I yearned for much finer controls. Finally in 1976 I decided to sell my old homemade frequency drive corrector and buy a new Geisler Model 2118A corrector drive unit as a Christmas present for myself. This model has the capability of correcting both coordinates using a joystick on the hand control box. I felt that having this versatile control would finally force me to design a small motorized declination drive system with a finer gearing system.

Since the mounting already had the main 325 tooth gear with its worm and mounting shaft, my objective was to design an additional motorized driving mechanism which would be small, lightweight, and move the telescope at a slightly slower rate in declination than the R.A. drive does in R.A. The new assembly also had to be easily mounted and removed.

First I needed to determine the correct additional gearing. Driven by a ½ r.p.m. motor, the 325:1 reduction was three or four times too fast; I'd have to gear it down. The original declination slow motion had two knurled knobs setscrewed to the worm shaft. It was a simple task to remove one and attach in its place a Boston Y3296 96-tooth spur gear. This gear is driven by a 32-tooth Y3232 spur gear which is driven by a ½ r.p.m.





synchronous reversible motor. The combination of gearing and motor causes the drive to move 11 seconds of arc in declination when a 1 second burst of current is applied to the motor. The polar drive, in 1 second of operation, moves the telescope in right ascension 15 seconds of arc, so my requirement had been met.

Next, and quite a challenge, came locating the small lightweight reversible synchronous motor of low speed. It became a most frustrating test of patience. I started looking for the motor in February 1977 and after no help from local motor suppliers, I found a source in a materials directory at the local public library. The one and only source was the North American Phillips Corporation of Cheshire, Connecticut and from their catalog a ½ r.p.m. motor was chosen. With the same dimensions as the well-known Cramer and Synchrom timing motors used for driving chart recorders and some commercial telescope drives, it appeared ideal. However, now my problems *really* began.

In dealing with this company, I quickly became aware that they were very impersonal, sometimes taking two or three weeks to answer an inquiry, and then found out why — they are "geared" to selling 100 motors at a time and not just one or two! In fact, for orders under $100 there was a $20 handling charge, and I wasn't about to pay $50 for one $30 motor. I decided to try to beat the system by writing the company a letter using the Astronomical Society of Kansas City's letterhead stating that the motor in question was to be used to serve the public and the Society would not be in favor of paying the $20 handling charge.

It worked! They finally wrote back that they would sell the motor for $30. I sent my order in right away but the subsequent wait of four months was a test of patience. Admittedly, it was worth waiting for since the motor works like a charm.

The total cost of this custom-made driving mechanism, including the motor, two extra gears and bushings, a few other associated items and machine work, came to $75.

Some Tips on Lenses...

Two lenses in my collection of astrophoto equipment are longer than normally used by amateurs: one, a 500 mm f/4.5 Asahi Pentax Super Takumar and the other, a 300 mm f/4 Perkin-Elmer Tessar with one surface of a lens aspherized for improved definition. This latter lens is especially interesting as it was designed for aerial photography. A directory of such lenses listed it as having unusually high definition and covering a 70 mm film frame (2¼" square pictures). As the accompanying picture shows, a photo of the region of the North American Nebula in blue light with a 35 mm camera has "fat" images, indicating that the lens is not corrected for blue light. All the visual focusing you can do will not produce better results.

You might have a lens like this, purchased government surplus with the highest hopes and abandoned as worthless several years later. Maybe you just didn't use it right. The key to understanding what happens with these lenses in blue light lies in the use of the lens for aerial photography. To penetrate haze and smog, most aerial lenses are used with red sensitive film and a filter to eliminate the blue light which is scattered by the atmosphere. They are, naturally enough, designed to produce sharp images only in the red region of the spectrum. A second picture of the same area was taken with 103a-E red sensitive film with a Wratten #22 (orange) filter and a 30 minute exposure. The improvement is so obvious that nobody could miss it!

Check any surplus lens used for astrophotography for its color focus, especially if it's a lens that was originally used for aerial photography. The images produced by many Aero Ektar f/2.5 lenses of 12-inch focus are "fat," so using film with greater red sensitivity and a "minus blue" (yellow) filter can help the final results. Of course, such lenses are not very good for color photography.

The 7" f/2.5 Aero-Ektar aerial lens is blue focused and has been used by many professional astronomers with 2¼" film for recording star fields. In many cases, it is sharper stopped down to f/4, yielding better overall field definition.

My guide telescope is a 3" f/10 Newtonian mounted in an oversize tube. Adjusting bolts at the front end permit shifting the 3" to locate a suitable guide star. Since I use lenses for my astrophotography, having the eyepiece near the objective end makes it much easier to cap and uncover the lens. This arrangement also helps avoid accidentally bumping the assembly in the dark.

The lights of Kansas City, Missouri are detrimental to astrophotography so I do most of my work 40 miles or more from home in the dark farmland regions of the state.

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If our readers know of reliable sources of small, high quality synchronous motors, we'd appreciate hearing about them from you.
--R.L.B.

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The Blue Pages

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Astroscopics
5617 Hawthorne St., Montclair, CA 91763

Cave Optical Co.
4137 E. Anaheim St., Long Beach, CA 90804
(213) 434-2613

Celestron International
2835 Columbia St., Torrance, CA 90503
(213) 328-9560

Coulter Optical Co.
Box K, 54121 Pinecrest Rd., Idyllwild, Ca 92349
(714) 659-2991

Dodd Co.
7795 W. Ridgewood Dr., Parma, OH 44129
(216) 886-2828

Edmund Scientific Company
101 E. Gloucester Pike, Barrington, NJ 08007

Meade Instruments Corporation
721 W. 16th St., Costa Mesa, Ca 92627
(714) 646-9281

OPTICA b/c
4100 MacArthur Blvd., Oakland, CA 94619
(415) 530-1234

R.V.R. Optical
P.O. Box 62, Eastchester, NY 10709
(914) 337-4085

Letters (con'd)

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telescope, it doesn't cost very much, and it works very well. I continue to use the prototype for observing from my backyard on a regular basis, and I'm very pleased with the near-perfect diffraction-limited images the $30 spherical mirror gives.

The "Telescopes for Beginners" articles, when they're published, should be of help to you. Beginners are too often referred to texts that assume you'll be making all the precision parts, grinding the mirror, and refiguring the secondary. This can all come later. What you need now are simple plans — easy to follow, easy to build, and inexpensive — to get you started. -- *R.L.B.*

Truth in Advertising

Dear Sir / After seeing the Celestron advertisement on pages 62 and 63 of the April ASTRONOMY, I felt a tremendous urge to comment to you. It was surprising in that I could not remember the magazine ever printing a more misleading ad. Questionable statements include the following: A) Refractors suffer from "color aberration" that, in principle, negate them somewhat as useful for planetary work. This is not true, and I wish that people who write ads would begin to realize that flint glass is used with crown glass in order to eliminate this objectionable phenomemon. B) Coma is not "very severe at the edges of the field" in f/10 and slower refractors. C) Rather than spend $10,000 for a 5" refractor, one DOES have the option to build a first-class instrument for well under the cost of a Celestron 8".

The price comparisons without detail as to accessories, or quality of glass or machinery, is a sales joke that people who read your magazine can live without. *James W. Stanis*
R.D. #1, Rt 40
Scenery Hill, PA 15360

Dear Mr. Stanis / Comments on the accuracy of advertising copy are best directed to the company in question, but I share your uneasy feeling about this ad. Celestron is a very "sexy" telescope, and can be sold without undercutting other instruments and manufacturers. -- *R. L. B.*

What's New?

new products of interest to telescope makers

Listings in this column in no way constitute an endorsement of any company or product.

Manufacturers please note that each item will be confined to a brief description and specifications.

Heat Sleuth

This is apparently a very sensitive differential thermometer: "a practical and systematic way to locate hidden heat leaks; traces small currents of infiltrating air." Meter will show air-temperature variations of 0.2° F to trace cold and hot air currents. Might be useful in the observatory for thermal control.

$39.95 from Edmund Scientific Company
7782 Edscorp Bldg.
Barrington, NJ 08007

Telescope News

If you're looking to buy used equipment, this little bi-monthly booklet of classified ads may help. Subscription at $5 for 6 issues (one year).

Typewritten, 8 pages, about 50 ads per issue, non-commercial ads $1 each.

Telescope News
P.O. Box 22486
Minneapolis, MN 55422

Erfle Eyepiece

A 32 mm wide-angle Erfle eyepiece for 2" focusing mounts. "Truly a classic design," claims Edmund, "best described as a giant porthole that gives the telescope user a wrap-around view." Stock number #41,347, it sells for $79.50; 30-day money-back guarantee.

Edmund Scientific Company
7782 Edscorp Bldg.
Barrington, NJ 08007

Calculator Software

TI-59 calculator programs to convert mis-aligned telescope setting circle coordinates into celestial coordinate system, and vice versa. Comes with complete instructions. Complete set of software $130. For more information, write to:

Deep-Sky Techniques
Box 100
Pocatello, ID 82301

Ray Tracing

A 36-page booklet on calculator techniques for ray-tracing optical systems. Includes discussion of basic problems, aberrations, problem examples, and keystroke sequences. $4.75 ppd in USA.

Innovative Optical Materiel
Box 243
Crest Park, CA 92326

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Photo by Scott Anderson

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